ENTERPRISES

1 CLUB CHAMBERS, ANNERLEY TERRACE
P.O. BOX 12298, CENTRAHIL, PORT ELIZABETH 6006
TELEPHONE (041) 52-3361

1987-01-22

RECEIVED
JAN 30 1987
J.D. DUNN

Mr Dave Dunn
Sohio Engineered Materials Company
P O Box 156
NIAGARA FALLS
NEW YORK 14302
USA

Dear Dave

* The attached copy letter and reprint from the Citrus and Subtropical Fruit Journal December 1980 is interesting.

I have written to Dr George Green as suggested and will let you know what he has to say when I get his reply.

With kindest regards

Charles.

C R MITCHELL

* Enclosures

SITRUSBEURS
CITRUS EXCHANGE

Suid-Afrikaanse Kooperatiewe Sitrusbeurs Beperk
(Geregistreer kragtens die Kooperasiewet 1981)

South African Co-operative Citrus Exchange Limited
(Registered under the Co-operatives Act 1981)

180 VISAGIE ST/STR 180, PRETORIA 0002 · P.O. BOX/POSBUS 1158, PRETORIA 0001
TEL. ADDR/ADR 'CITRANGE' · TELEX/TELEKS 3-21391 SA · TEL (012) 28-2181

Ref. No./Verw. Nr. X55 Date/Datum 14 January 1987

Mr C R Mitchell
CIA Enterprises
P O Box 12298
CENTRAHIL
Port Elizabeth
6006

Dear Mr Mitchell

SCHEDULER PLANT STRESS MONITOR

Your letter dated 6 October 1986 refers.

Personally I have no knowledge of this type of instrument and therefore referred your query to certain of our research people. Their replies are attached. You will see that no-one is particularly optimistic.

I would suggest that you also refer your enquiry to Dr George Green. His address is:

Water Research Commission
P O Box 824
Pretoria 0001

Tel. 28-5461

Yours sincerely

D A Stanton.

Dr D A Stanton
DIVISION MANAGER, TECHNICAL

/ldb

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CITRUS EXCHANGE
South African Co-operative Citrus Exchange Limited
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Ref. No.

Date 1986.10.28

R+T 1
File No.: X55
Index Key:
31 OCT 1986
Date Received:
Date Replied:

Division Manager Technical,
S.A. Co-op Citrus Exchange Ltd.,
P.O. Box 1158,
PRETORIA.
0001.

Dear Doug,

INFRARED THERMOMETER

Your memo "Irrigation Scheduler" of the 14th October, 1986 refers.

This is probably an improved infrared thermometer as described in the attached reprint from the Citrus and Subtropical Fruit Journal, December, 1980.

I stopped off in Phoenix on my trip to the US in 1982 and visited Dr. Idso. They were using the 'gun' on lucerne at the time of my visit. It works very successfully on irrigated field crops, and would probably work well on citrus if one could get the readings from above the canopies of the trees from a platform.

Water Affairs in Pretoria have an infrared gun and I believe George Green has worked with it. I think he would be the best contact for Mr. Mitchell to approach.

Sincerely,

Ian

DR. I. GILFILLAN
Research Manager - Horticulture.

/JDeG.

References

1 Anon., 1968. Export and local market grading standards for Colour (set 19) and creasing (set 29). In *Colour Prints for Blemish Standards prescribed by the Citrus Export and Local Market Regulations for Citrus.* Published by the South African Cooperative Citrus Exchange, Pretoria.
2 Anon., 1975. Urea phosphate usage for the prevention of creasing in oranges. South African Patent 7517873 (*pending*). Chemicals and Phosphates Ltd., Haifa, Israel.
3 Berka, O and D. Griedinger. 1978 and 1979. Private communications.
4 Bar-Akiva, A. 1975. Effect of foliar application of nutrients on creasing of valencia oranges. *Hortscience,* 10:69-73.
5 Gilfillan, I M, J A Stevenson and W Koekemoer. 1974. Gibberellic acid reduces creasing in late-season navels. *Citrus and Subtropical Fruit Journal,* 482:4-5.
6 Gilfillan, I M and J A Stevenson. 1979. Preharvest and postharvest use of ethephon for improving the colour of citrus fruit. *Annual Report,* Research Horticulturist, Research and Technical Department, SA Coop Citrus Exchange, Nelspruit.
7 Holmden, E A. 1980. Personal communication.
8 Monselise, S P. 1973. Fruit quality in citrus and the effect of growth regulators. *Acta Horticulturae,* 34:457-468.
9 Monselise, S P, M Weiser, N Shafir, R Goren and E E Goldschmidt. 1976. Creasing of orange peel – physiology and control. *J. Hort. Sci.,* 51:341-351.

Infrared thermometer Triggers irrigation

From Agricultural Research/September 1980

Research entomologist Paul Pinter takes aim at cotton with an infrared thermometer. By measuring plant and air temperatures and computing the difference, the thermometer detects plant "stress", the plant's plea for water (PN-6811).

Space age technology has caught up with irrigation management.

Irrigators, using an infrared "gun" can now take the temperature of a crop canopy – the foliage – and relate that temperature to surrounding air temperature, enabling the irrigator to determine when to irrigate a crop for maximum yields. The idea promotes irrigation efficiency and saves water and energy.

When soil moisture falls below the plant's needs, the plant becomes *"stressed"* and its temperature rises. When crop temperature exceeds that of the air for a certain length of time – which varies among different crops and soils – it's time to irrigate.

The concept of using the difference in the plant and air temperatures as a guide for efficient irrigation management has been under study for the past few years by SEA scientists at the U.S. Water Conservation Laboratory in Phoenix, Ariz.

When the study began, the researchers were using cumbersome infrared thermometers to measure canopy temperatures and regular thermometers to read air temperatures. They then computed the difference. The unwieldiness of that equipment prompted the scientists to write specifications for a gun that would make both readings and give a digital readout of the difference. Such a gun is now on the market. It weighs about 2 pounds, is operated by a trigger, and has rechargeable batteries.

The gun gives readings of the temperature difference between the crop and air surrounding the crop. When readings come up on the plus side, an irrigator knows it's nearing the time to apply water. Readings are made during the hottest part of the day, around 1:00 p.m. in Arizona.

SEA physicists Ray D. Jackson and Sherwood B. Idso and SEA soil scientist Robert J. Reginato, conceived the concept and are tuning it to finer, more precise efficiencies.

The trio has developed a system they call *"stress-degree-days"*. Wheat, for instance, on Phoenix area soils has a tentative stress-degree-day classification of +10. If the differential reading on a wheat field one day is +2, the next day +3, and the following day +5, the total accumulation of +10 indicates that the crop needs water. Alfalfa and other crops have different stress-degree-day classifications.

The stress-degree-day concept and the infrared gun are being compared to other irrigation treatments in the Wellton-Mohawk area of Arizona near Tacna, in cooperation with the Bureau of Reclamation.

One treatment uses Bureau of Reclamation irrigation guides and checks soil moisture with neutron moisture probes. Another treatment, based on a theory developed by Leonard J. Erie, SEA agricultural engineer, calls for irrigation after 65 percent of the available moisture in the top 3 feet of soil has been depleted. Four other plots are being irrigated when the accumulate +5, +10, +15, and +20 stress-degree-days.

Infrared temperatures of crops can be taken from ground level, high-flying aircraft, or space satellites, opening up countless uses for the concept.

Dr. Ray D. Jackson, Dr. Sherwood B. Idso, and Dr. Robert J. Reginato are located at the U.S. Water Conservation Laboratory, 4331 E. Broadway Road, Phoenix, AZ 85040. – (By Paul Dean, SEA, Oakland, Calif.)

M E M O

X 55

To: DMT

From: E. Rabe

21 October 1986

Irrigation Scheduler

Mr Mitchell claims that the Scheduler arrives at optimum irrigation scheduling by taking into account diseases, insect damage, soil compaction and soil type. I can see that this device can derive at an irrigation schedule by measuring leaf and ambient temperatures, solar radiation and relative humidity. However, it is difficult for me to envisage how disease infection and insect damage would alter these measurements and how the Scheduler can actually monitor it. The brochure does not make these claims either.

With the stress metabolism (nutrition and disease infection) research which I plan it would be a good opportunity to evaluate these claims. He'll be wellcome to come and demonstrate his claims. Otherwise, I share your skepticism.

/mb

M E M O

AAN: A B T 31 Oktober 1986

VAN: J COETZEE X47

"IRRIGATION SCHEDULER"

Na aanleiding van aangehegte memo en pamflet, my kommentaar soos volg:

Nêrens word gesê wat die basis is waarop die instrument werk nie. Dit lyk na 'n infrarooi termometer.

Die vernaamste besware teem I R termometers is dat dit relatiewe waarnemings maak wat omgeskakel moet word na waterbehoefte. Dit moet dus goed gekalibreer wees. Om dit te kalibreer moet die lesings voor sonop en weer teen 10h00 op 'n spesifieke vaste punt geneem word. Alle waarnemings daarna moet ook op die tye en plek gedoen word.

'n Hulpmiddel in navorsing en dit kan 'n lekker speelding vir die kweker wees maar nog ver van 'n instrument om skedulering mee te doen.

J COETZEE

/jcd

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Sensor Technologies
6180 Cochran Road
P.O. Box 391316
Solon, Ohio, 44139
216 349-6881

Bronson

STANDARD OIL
ENGINEERED MATERIALS

March 17, 1987

Mr. G. C. Green
Water Research Commission
P.O. Box 824
Pretoria, South Africa

Dear Mr. Green:

Your recent letter to Mr. C. A. Mitchell concerning the Scheduler Plant Stress Monitor has been referred to me. It is clear that you have a very sound understanding of the prinicples associated with this instrument. You ask some important questions, which I will respond to.

First, with regard to the suitability of the sensors. Both the air temperature and humidity sensors are aspirated and shielded from direct exposure to solar radiation. We recommend an initial equilibration time of 3 to 5 minutes after the sensor head is removed from the carrying pouch and the fan becomes operational for the sensors to equilibrate. The ambient sensor is accurate to within $0.1^{o}C$, the humidity sensor to within +/- 5%. The infrared thermometer (IRT) is accurate to within +/- $0.5^{o}C$ (with a resolution of $0.1^{o}C$), unless a user subjects it to large step changes in ambient temperature. For example, if the IRT experiences an instantaneous change in ambient of $20^{o}C$, then IRT errors of $1^{o}C$ or more may result. Even in this case, the instrument will respond reasonably well. The solar radiation sensor consists of two photodiodes. Their purpose is to determine whether or not a cloud is in front of the sun or if solar radiation intensity is sufficiently high for our algorithm to function properly. The configuration of these diodes allows for approximately constant response under clear skies regardless of time of day (except near sunrise and sunset).

You are correct in stating that factors other than declining soil water content cause transpirational decreases. The Scheduler does not determine the cause of decreased transpiration. The proper use of the Scheduler requires a knowledge and understanding of the crop and field on which it is being used.

With regard to irrigation amounts, the Scheduler provides indirect feedback. By noting the length of time required for a crop to exhibit stress (ranging from a very short to a very long time) a farmer can adjust calibrate the recommendations of a water balance program to his particular field. We have found this to be an effective approach. Another effective approach is to simply guess an amount, note the length of time between stress events and iterate between irrigation frequencies and amounts until the desired stress pattern is achieved. Some user try to hold stress levels constant for high cash value crops, such as tomatoes but prefer to let the stress pattern sawtooth on less valuable crops, such as corn. Our research has shown a high correlation between soil moisture depletions and Scheduler readings.

One of the strengths of this unit is its ease of use and the supporting educational materials which are available. I strongly feel the ordinary farmer would find this instrument easy to use and beneficial in many ways. When related to the value of the crops and the cost of water/energy the price of the Scheduler is affordable. We have done all we can to assure the components we use are of the highest quality and that the sensors are properly exposed.

Sincerely,

Bronson Gardner

Bronson Gardner
Product Technical Manager

BG/lb

cc: J. D. Dunn
C. A. Mitchell

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Engineered Materials Company
Sensor Technologies
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SENSOR TECHNOLOGIES

November 23, 1978

Dr. Charles Krauter
Department of Plant Science
Fresno State University
Fresno, CA 93740-0072

Dear Charlie:

Attached is a brief summary of the cantaloupe data and the SAS program which generated it. Thank you for all that you've done this year.

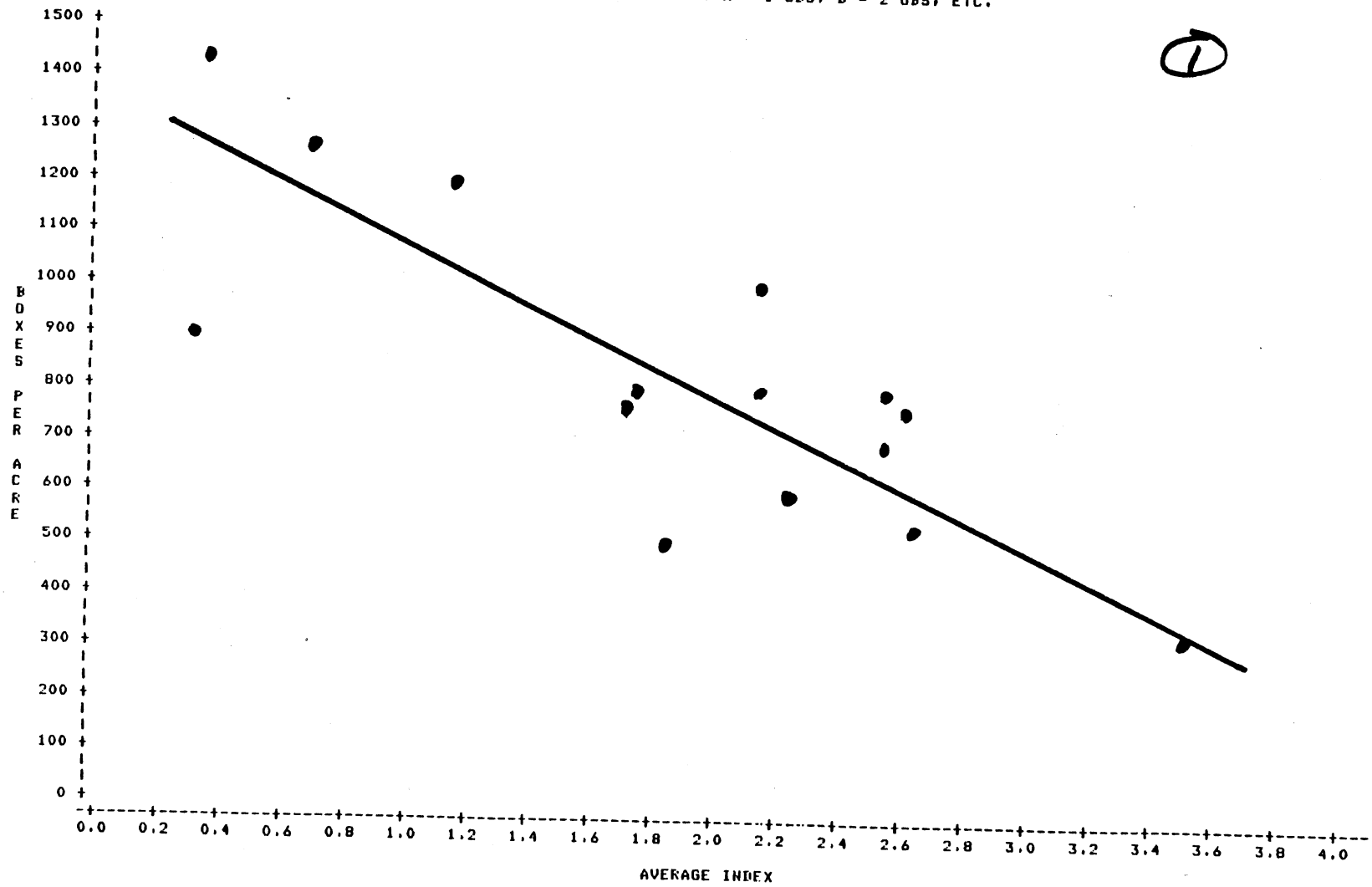
Sincerely,

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987
BOXES/ACRE = TOTAL BOXES OF 13,18 AND 24 MELONS/BOX
DATES OF MEASUREMENT : JUNE 3 - JULY 14, 1987

PLOT OF YIELD*INDEX LEGEND: A = 1 OBS, B = 2 OBS, ETC.



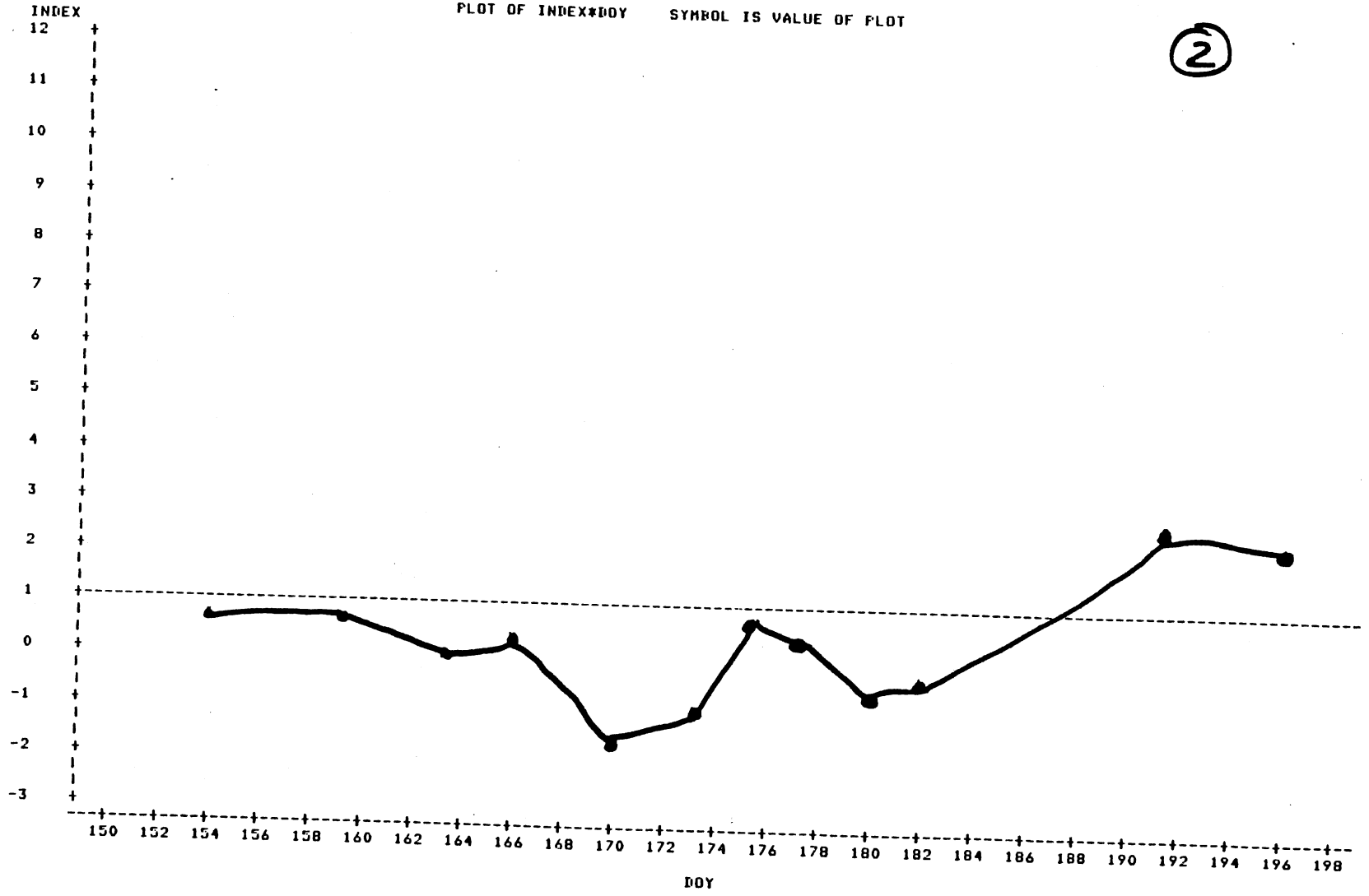
CANTALOUPE INDEX TRENDS --FRESNO,CALIF.,, 1987
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

15:28 FRIDAY, NOVEMBER 20, 1987 7

BOXES PER ACRE=1444 PLOT=blk

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(2)

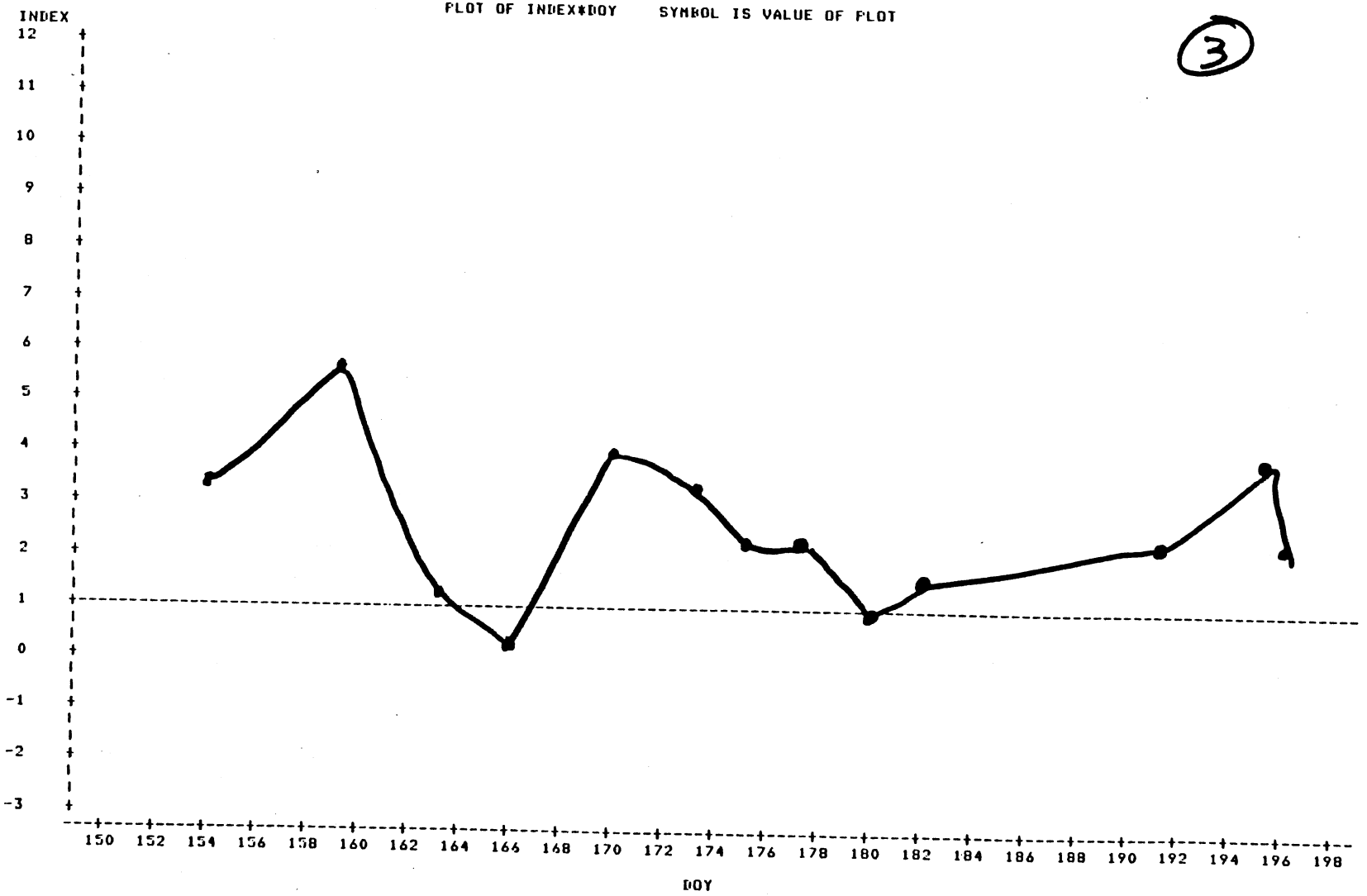


CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987 15:28 FRIDAY, NOVEMBER 20, 1987 6
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=758 PLOT=c6--A

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(3)

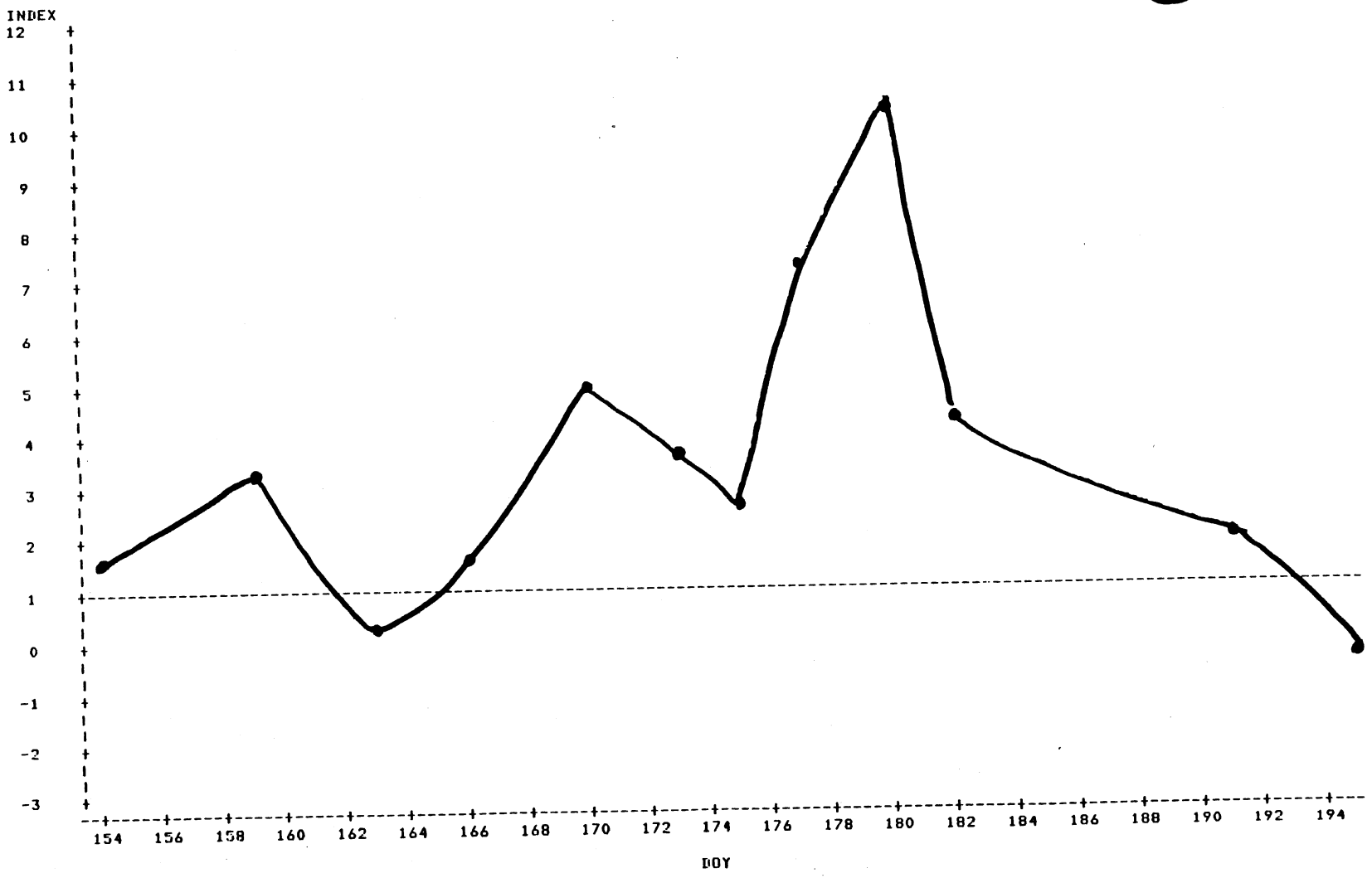


CANTALOUPE ...
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=348 PLOT=c12-A

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(4)

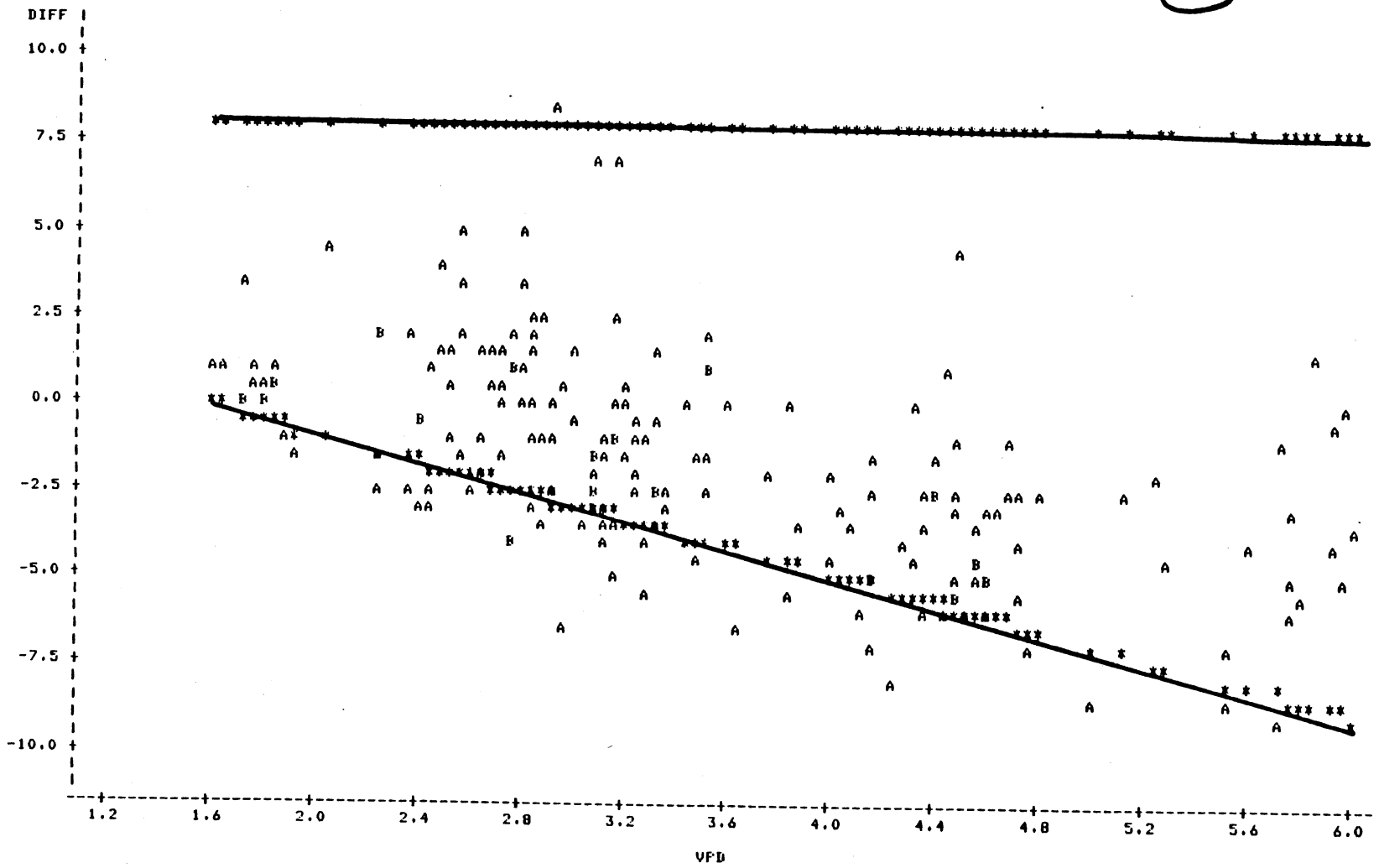


CANTALOUPE VPD RELATIONSHIP
DATES OF MEASUREMENT : JUNE 3 - JULY 14, 1987

13:28 FRIDAY, NOVEMBER 20, 1987 16

PLOT OF DIFF*VPD LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF MIN*VPD SYMBOL USED IS *
PLOT OF MAX*VPD SYMBOL USED IS *

(5)



NOTE: 223 OBS HIDDEN

```
DATA ONE;INFILE CANTAL FIRSTOBS=18;
INPUT DATE $ TIME PLOT $ TA TC RH SUN CWSI VPDS;
DROP VPDS;
MONTH=SUBSTR(DATE,4,3);
DAY=SUBSTR(DATE,1,2);
IF MONTH ='Jul' THEN DOY =181+DAY;
IF MONTH='Jun' THEN DOY=151+DAY;
TRT=SUBSTR(PLOT,5,1);
IF PLOT EQ 'blk' THEN YIELD=722;
IF PLOT EQ 'blue'  THEN YIELD=627;
IF PLOT EQ 'red' THEN YIELD=450;
IF PLOT EQ 'c9--A' THEN YIELD=595;
IF PLOT EQ 'c12-A' THEN YIELD=174;
IF PLOT EQ 'c1--A' THEN YIELD=403;
IF PLOT EQ 'c6--A' THEN YIELD=379;
IF PLOT EQ 'c11-B' THEN YIELD=394;
IF PLOT EQ 'c8--B' THEN YIELD=352;
IF PLOT EQ 'c3--B' THEN YIELD=385;
IF PLOT EQ 'C2--B' THEN YIELD=504;
IF PLOT EQ 'c7--C' THEN YIELD=249;
IF PLOT EQ 'c10-C' THEN YIELD=259;
IF PLOT EQ 'c5--C' THEN YIELD=392;
IF PLOT EQ 'c4--C' THEN YIELD=300;
* THE ABOVE YIELDS ARE FOR 27, 36, AND 45 MELONS PER CARTON;
* COVERT THESE YIELDS TO 14, 18 AND 23 MELON PER CARTON;
YIELD=YIELD*2;

LABEL YIELD='BOXES PER ACRE';
DIFF=TC-TA;
VPD=(1-RH/100)*(0.61078*EXP(17.2693882*TA/(TA+237.3)));
A=3.0;B=-1.97;
MIN=A+B*VPD;
MAX=8;
IF VPD LT 1 THEN MIN=A+B;
INDEX=10*(DIFF-MIN)/(MAX-MIN);
PROC PLOT;PLOT DIFF*VPD MIN*VPD='*' MAX*VPD='*'/OVERLAY;
TITLE 'CANTALOUPE VPD RELATIONSHIP';
TITLE2' DATES OF MEASUREMENT :  JUNE 3 - JULY 14, 1987';
PROC SORT;BY YIELD PLOT;
PROC MEANS ;BY YIELD PLOT;
VAR INDEX ;
OUTPUT OUT=NEXT
MEAN=INDEX ;

DATA TWO;SET NEXT;
LABEL INDEX='AVERAGE INDEX';
TITLE 'CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987';
TITLE2'BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX';
TITLE3' DATES OF MEASUREMENT :  JUNE 3 - JULY 14, 1987';
PROC PLOT;PLOT YIELD*INDEX ;

DATA TWO;SET ONE;
IF YIELD=348 OR YIELD=758 OR YIELD=1444;
TITLE 'CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987';
TITLE2'BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX';
TITLE3' DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987';

PROC SORT;BY YIELD PLOT;
PROC PLOT;PLOT INDEX*DOY=PLOT /VAXIS=-3 TO 12
VREF=1;BY YIELD PLOT;
```

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6180 Cochran Road
Solon, Ohio 44139
216 349-6881

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November 23, 1987

Dr. Carole Whittaker
3320 E. Shea Boulevard #290
Phoenix, AZ 85028

Dear Carole:

I have been successful in defining a baseline for jojoba (Mirov variety). The data attached comes from rows 48, 50, 52 and 54 at Hal Purcell's. It is clear that the row with the lowest index (row 54) had the highest average seed size and the greatest number of new buds per branch in the fall. I hope this data is helpful to you.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

A unit of the original Standard Oil Company
founded in Cleveland, Ohio, in 1870.

JOJOBA STRESS INDEX PATTERNS! MCVAY JOJOBA, 1987 (MIROV VARIETY)
ROW=48 NEW BUDS/BRANCH=1.7 SEED SIZE = 0.25 GRAMS/SEED 16:51 FRIDAY, NOVEMBER 20, 1987
HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

ROW=48

PLOT OF INDEX*DOY LEGEND! A = 1 OBS, B = 2 OBS, ETC.

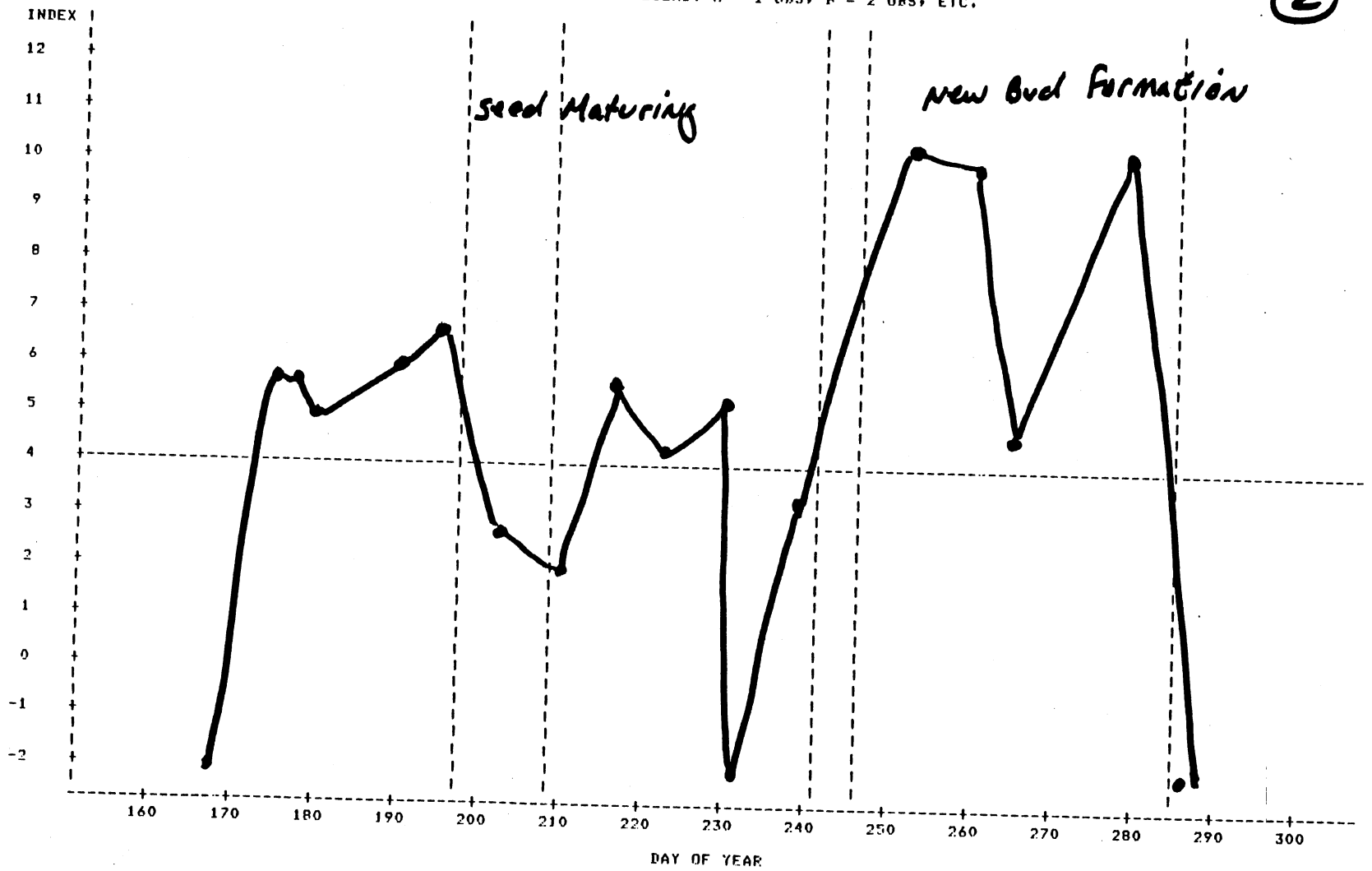
JOJOBA STRESS INDEX PATTERNS: MCVAY JOJOBA, 1987 (KIROV VARIETY)
ROW=50 NEW BUDS/BRANCH= 2.7 SEED SIZE=0.65 GRAMS/SEED
HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

16:51 FRIDAY, NOVEMBER 20, 1987

ROW=50

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

(2)



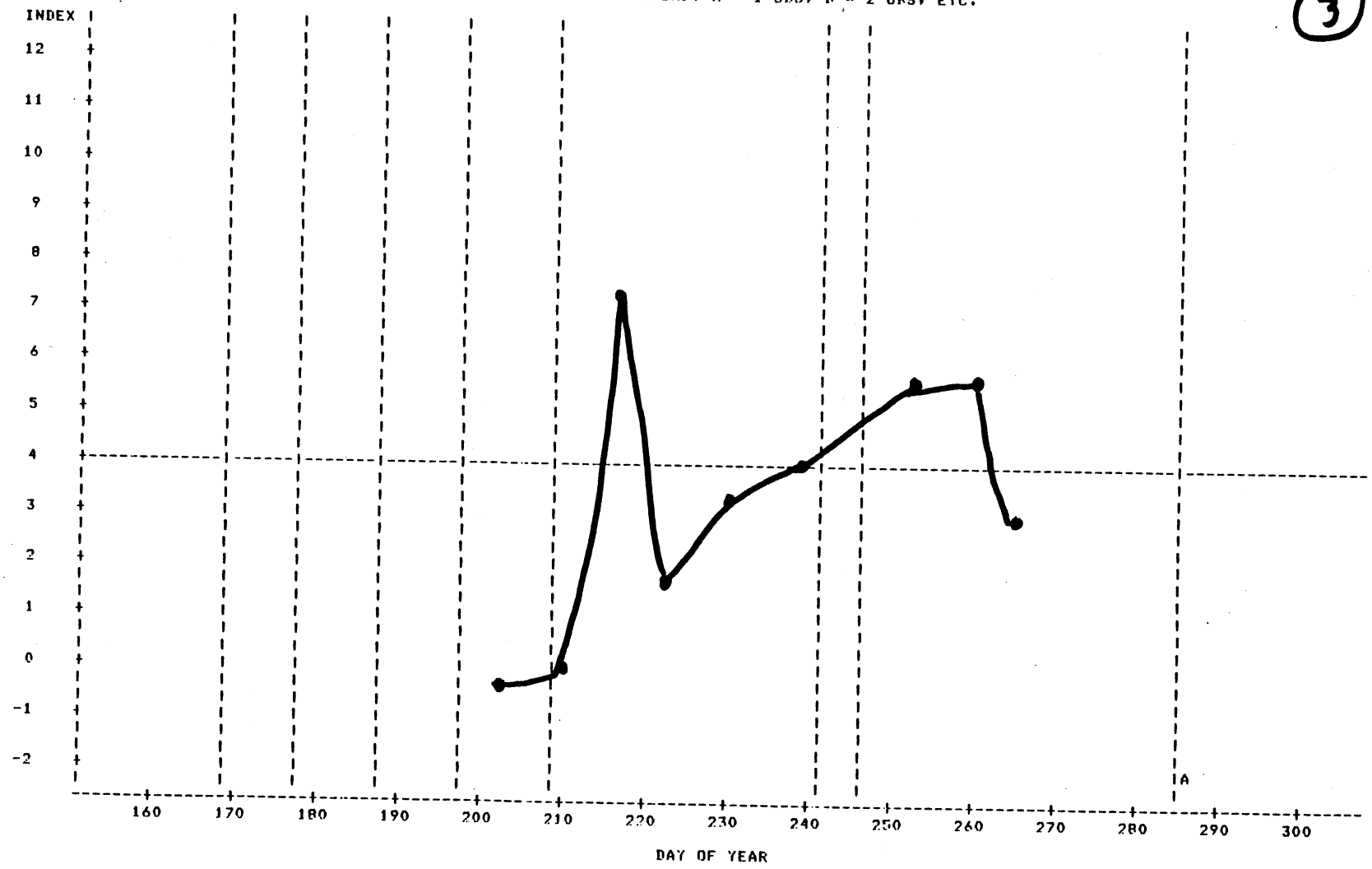
JOJOBA STRESS INDEX PATTERNS: MCVAY JOJOBA, 1987 (MIROV VARIETY)
ROW=52 NEW BUDS/BRANCH= 3.0 SEED SIZE = 0.75 GRAMS/SEED
HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

16:51 FRIDAY, NOVEMBER 20, 1987

ROW-52

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

(3)



EMBER 20, 1987

JOJOBA STRESS INDEX PATTERNS: MCVAY JOJOBA, 1987 (MIROV VARIETY)
ROW=54 NEW BUDS/BRANCH=4.4 SEED SIZE = 0.75 Grams/acre

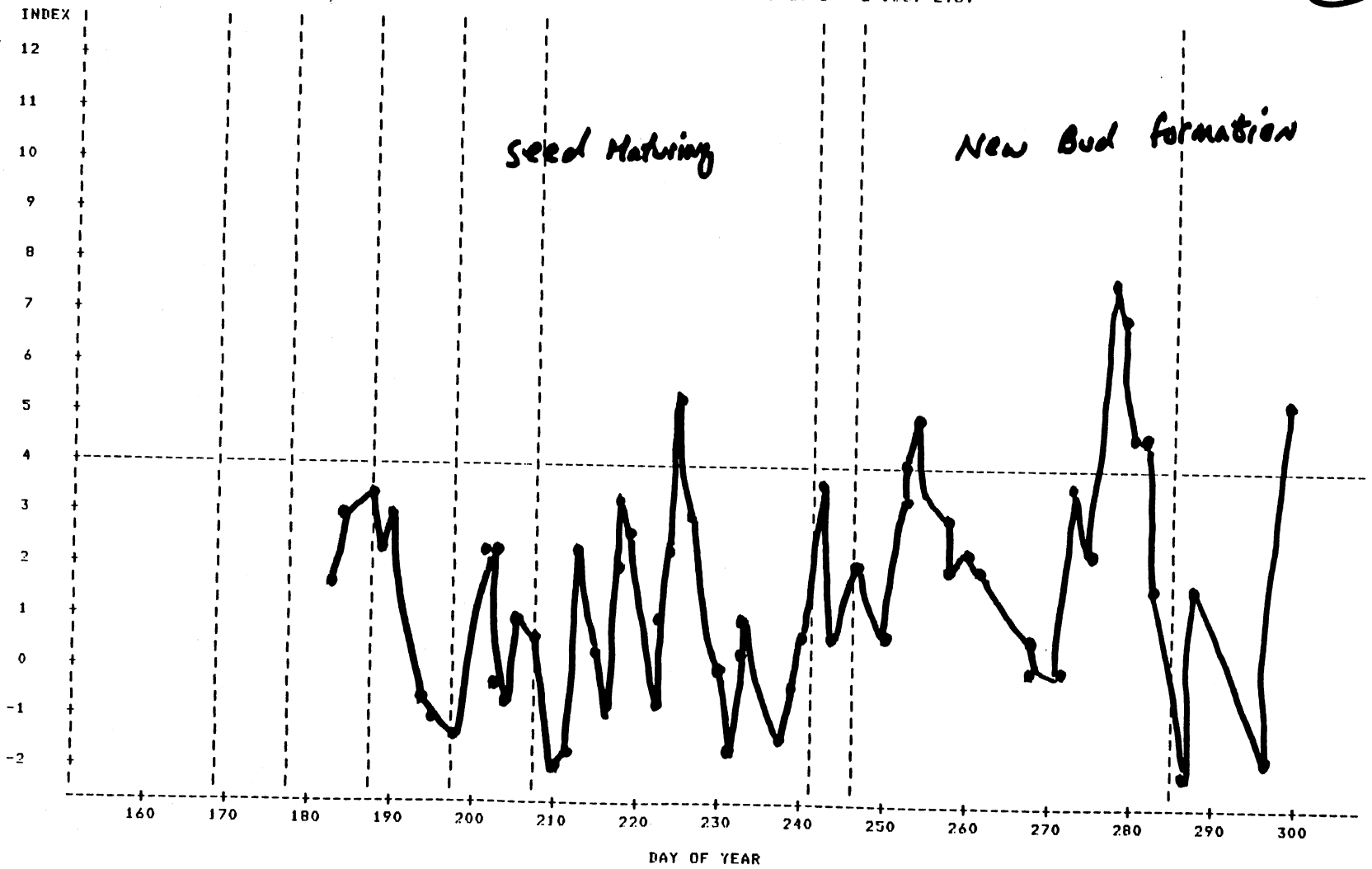
16:51 FRIDAY, NOV

HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

ROW=54

PLOT OF INDEX$DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

(4)



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November 23, 1987

Dr. Greg Jorgensen
California State University, Fresno
Center for Irrigation Technology
Fresno, CA 93740-0018

Dear Greg:

Thank you for the yield data. Enclosed is my analysis of the Scheduler^{R} Plant Stress Monitor data. I converted the yield data to boxes per acre. The box sizes I assumed were 14, 18 and 23 melons per box. The yields given are twice that had I assumed 27, 36 and 45 melons per box. The total boxes per category were summed. I felt this would provide growers with something they could relate to. Again, I appreciate the information. It made an important contribution to this analysis.

Sincerely,

Bronson Gardner

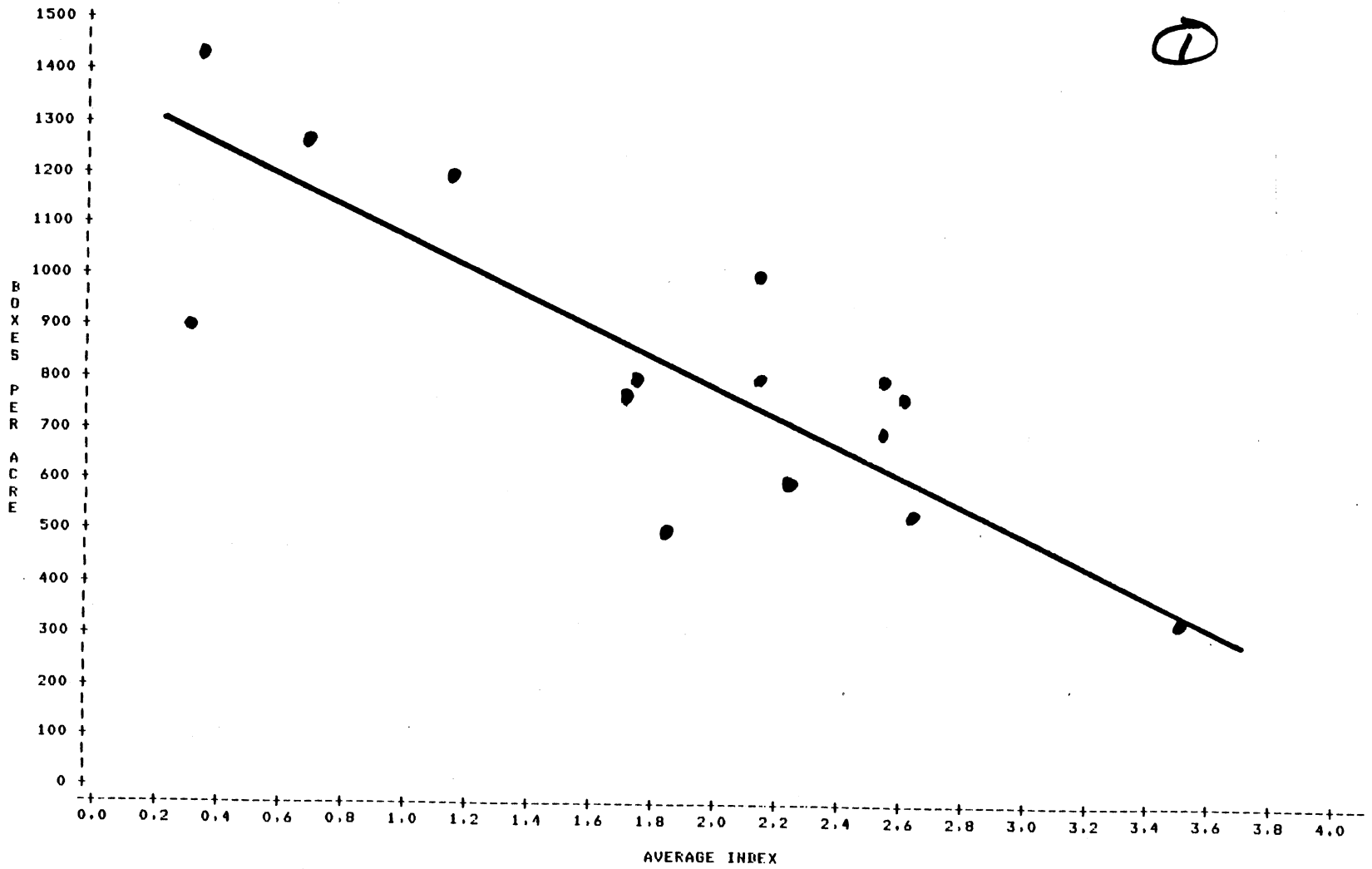
Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987
BOXES/ACRE = TOTAL BOXES OF 13,18 AND 24 MELONS/BOX
DATES OF MEASUREMENT : JUNE 3 - JULY 14, 1987

13:28 FRIDAY, NOVEMBER 20, 1987 17

PLOT OF YIELD*INDEX LEGEND: A = 1 OBS, B = 2 OBS, ETC.

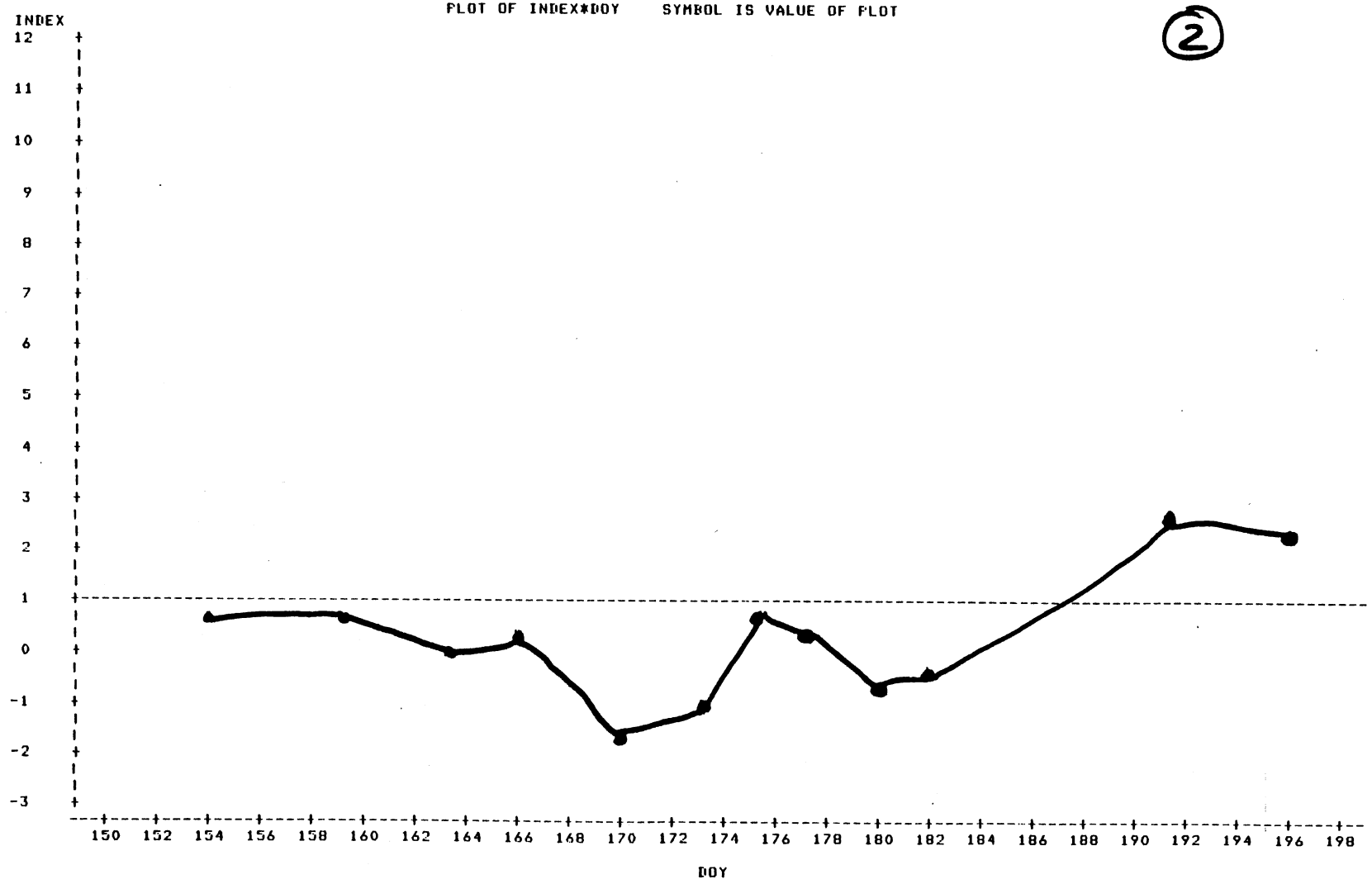


CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=1444 PLOT=blk

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(2)

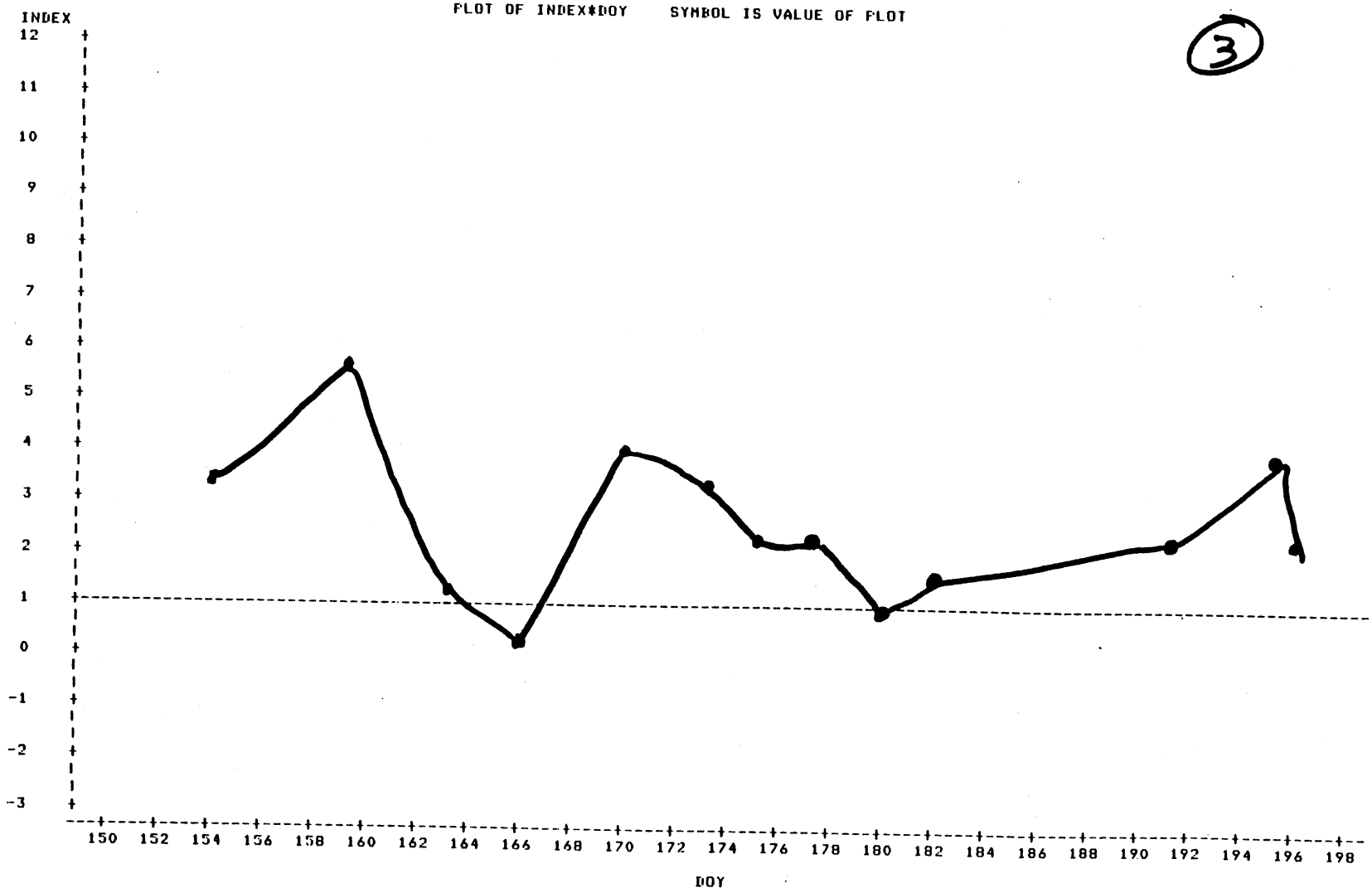


CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=758 PLOT=c6--A

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

3

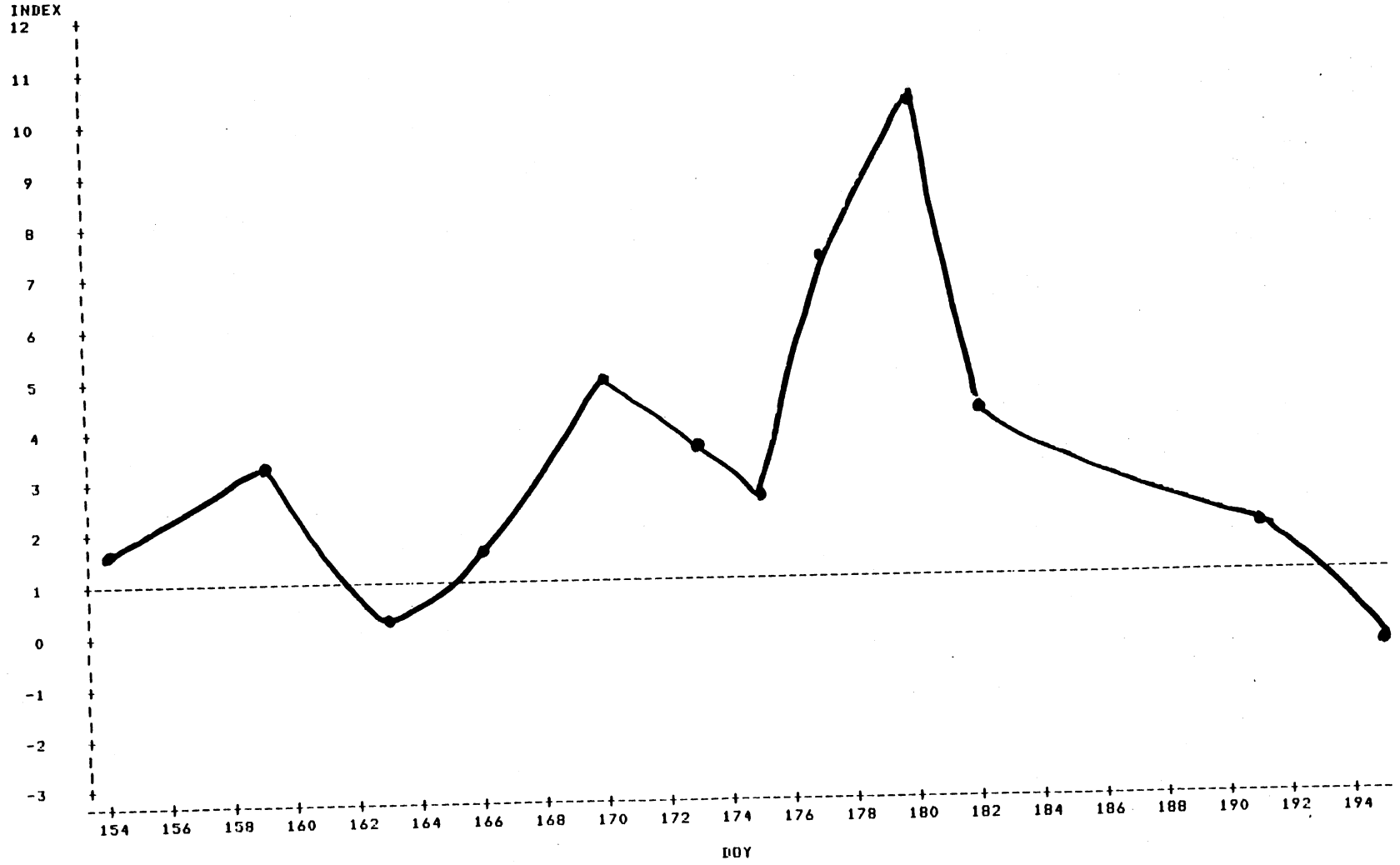


CANTALOUPE [illegible]
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=348 PLOT=c12-A

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(4)



Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

November 23, 1987

Mr. Hal Purcell
142 Front Street
Avila Beach, CA 93424

Dear Hal:

Thank you for all your efforts this year in providing me with baseline data. I have been successful in defining a baseline for jojoba. Attached are graphs which show the index trends for rows 48, 50, 52 and 54. The trends clearly show that row 54 was generally cooler than the other rows. Row 48 was generally the hottest. Row 50 was in between. This pattern follows the yield, new bud formation, and seed size data you gave me. These graphs show that irrigation should be conducted to maintain the index levels between -2 and +4.0. Congratulations on a good research year. I look forward to our continued association.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

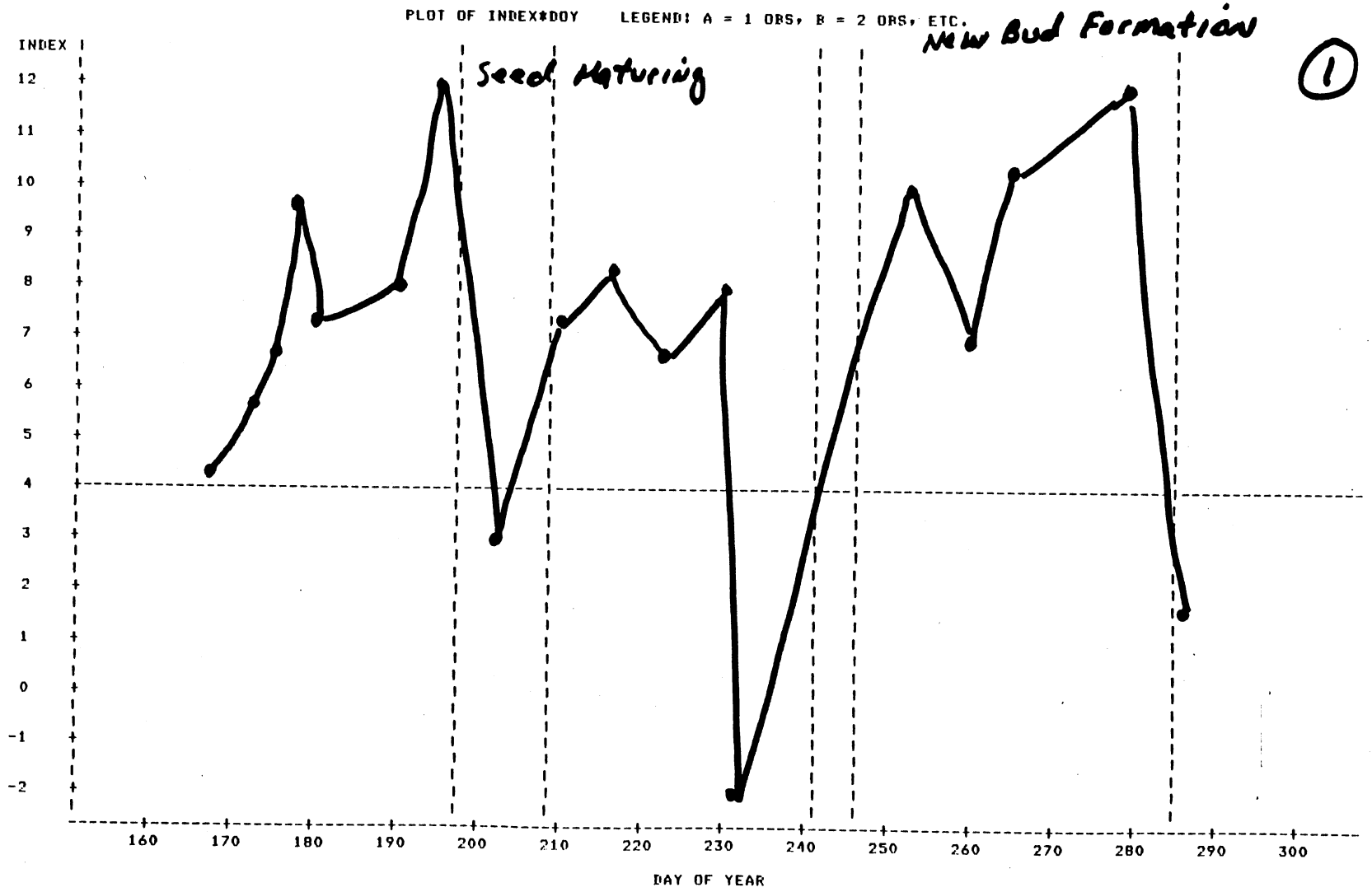
BRG/lb

cc: M. Purcell

JOJOBA STRESS INDEX PATTERNS! MCVAY JOJOBA, 1987 (MIROV VARIETY)
ROW=48 NEW BUDS/BRANCH=1.7 SEED SIZE = 0.25 GRAMS/SEED 16:51 FRIDAY, NOVEMBER 20, 1987
HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

ROW=48

PLOT OF INDEX*DOY LEGEND! A = 1 OBS, B = 2 OBS, ETC.



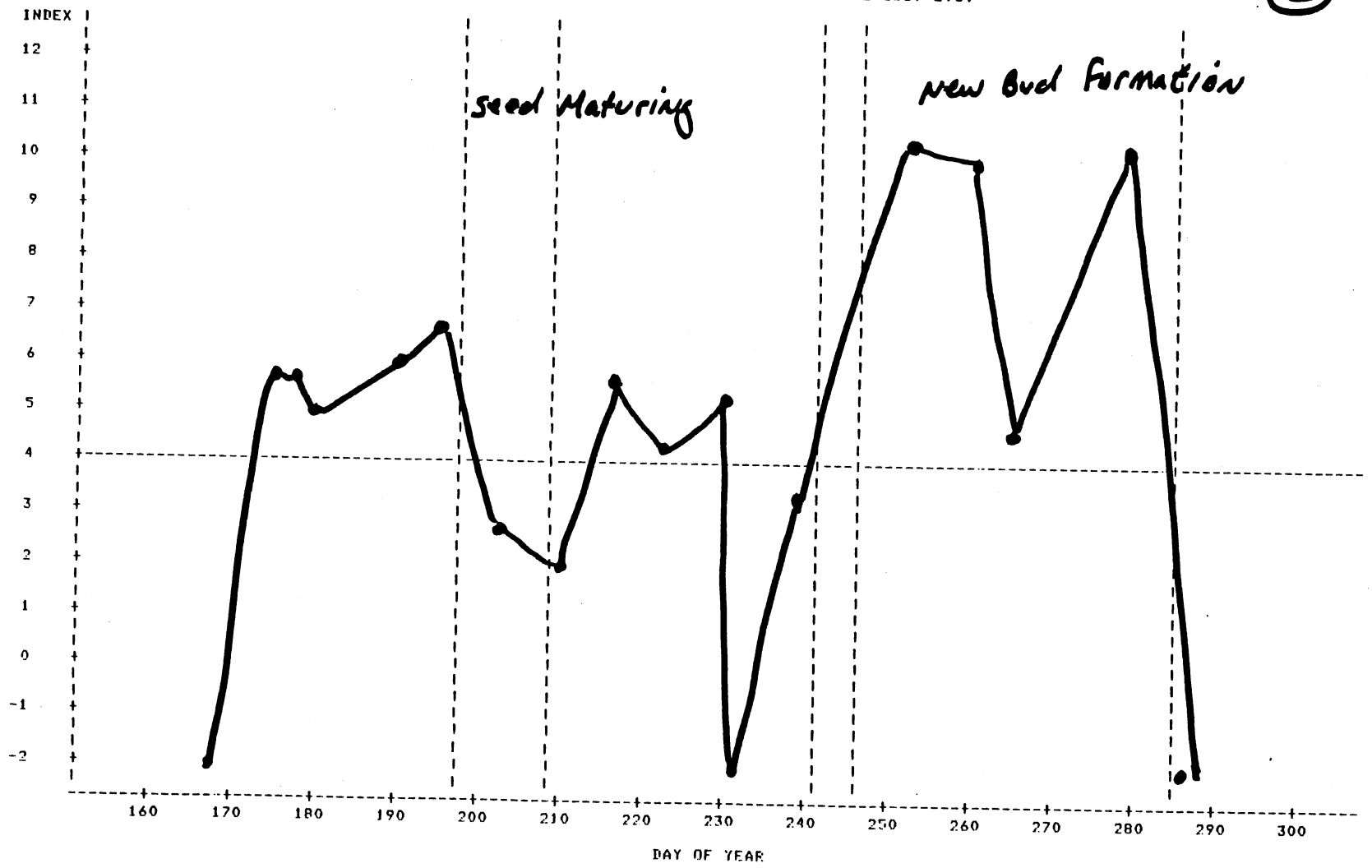
JOJOBA STRESS INDEX PATTERNS: MCVAY JOJOBA, 1987 (KIROV VARIETY)
ROW=50 NEW BUDS/BRANCH= 2.7 SEED SIZE=0.65 GRAMS/SEED
HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

16:51 FRIDAY, NOVEMBER 20, 1987

ROW=50

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

(2)



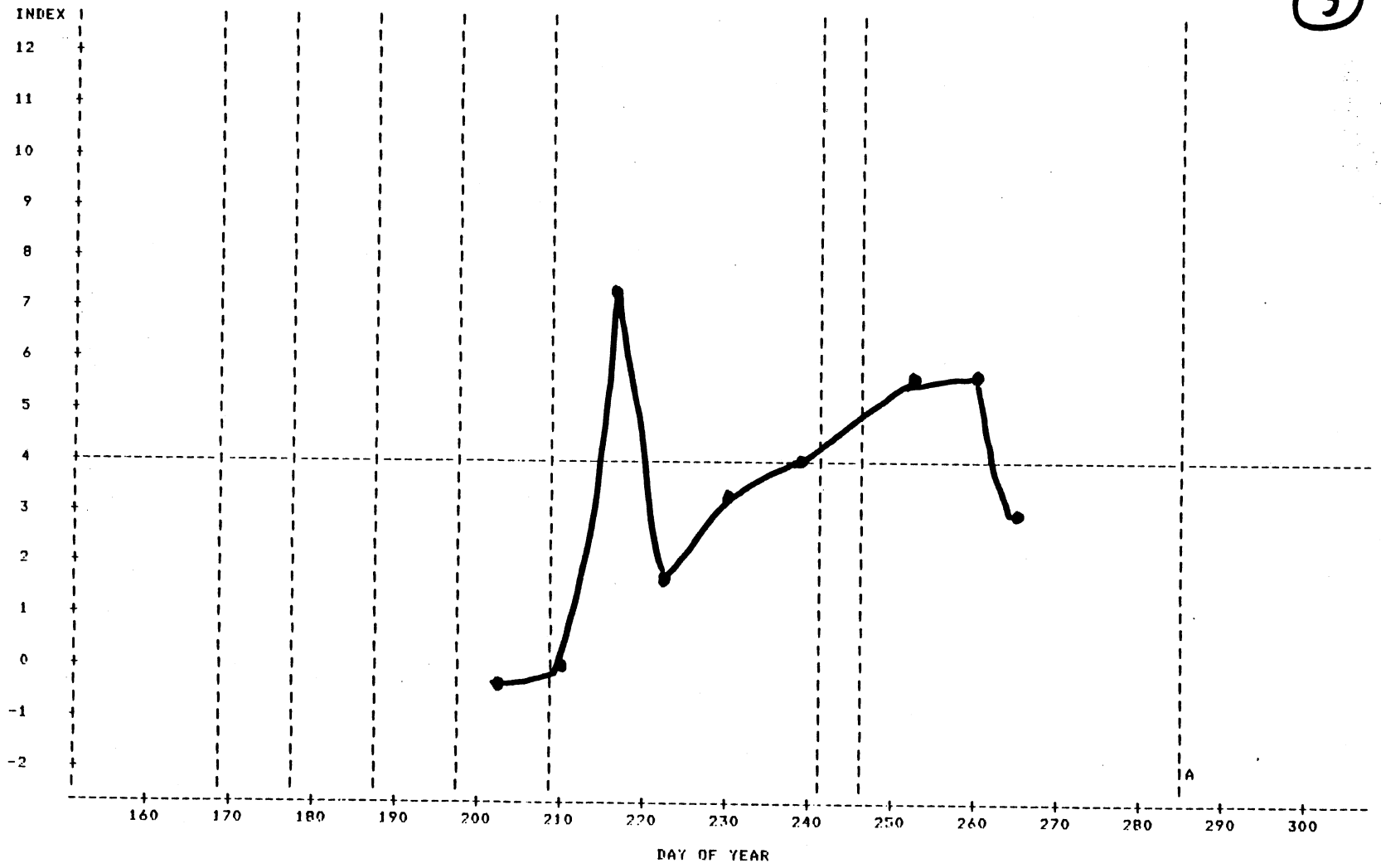
JOJOBA STRESS INDEX PATTERNS: MCVAY JOJOBA, 1987 (MIROV VARIETY)
ROW=52 NEW BUDS/BRANCH= 3.0 SEED SIZE = 0.75 GRAMS/SEED
HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

16:51 FRIDAY, NOVEMBER 20, 1987

ROW=52

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

(3)



EMBER 20, 1987

JOJOBA STRESS INDEX PATTERNS: MCVAY JOJOBA, 1987 (MIROV VARIETY)
ROW=54 NEW BUDS/BRANCH=4.4 SEED SIZE = 0.75 Grams/acre

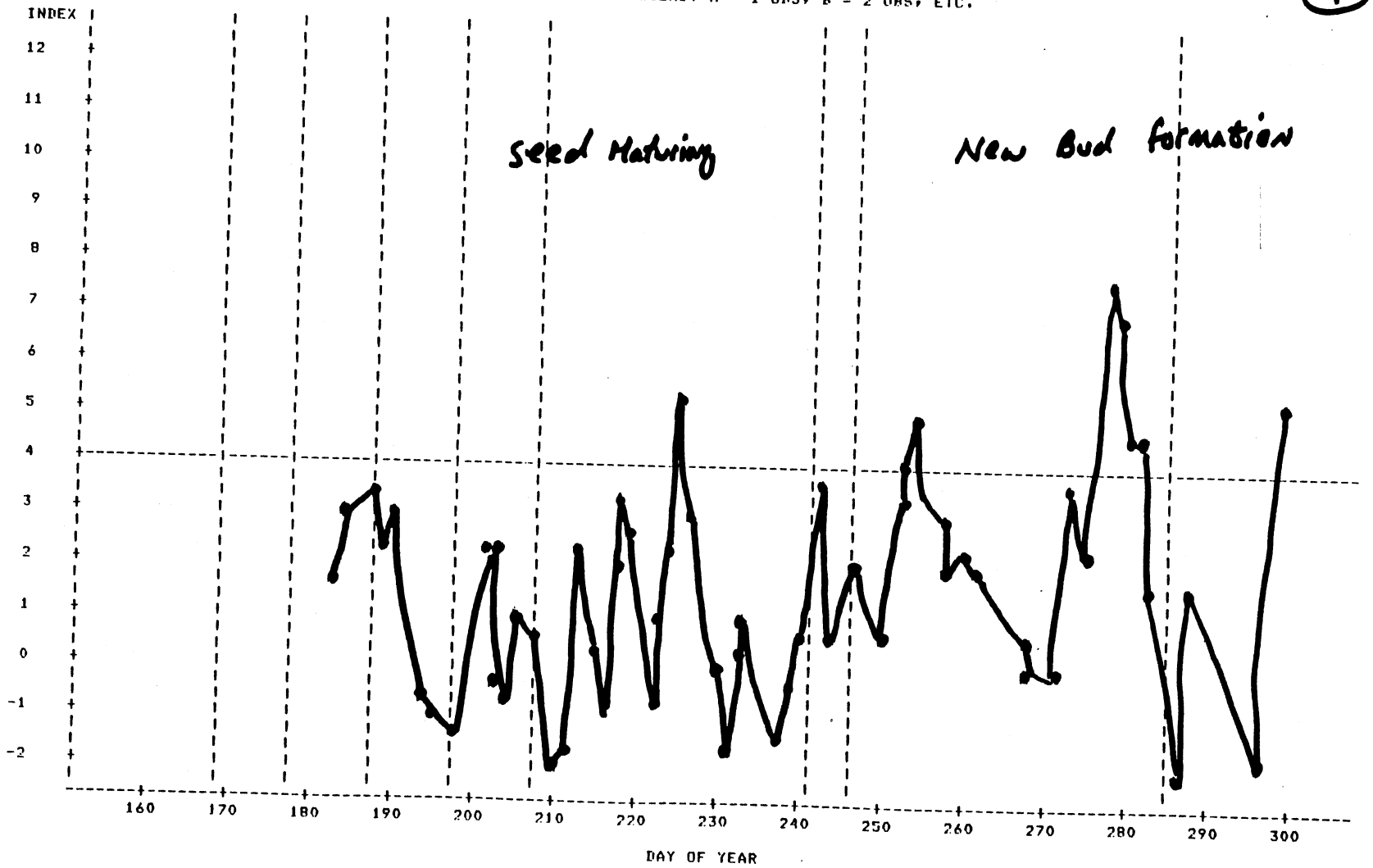
16:51 FRIDAY, NOV

HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

ROW=54

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

4



Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

December 1, 1987

Dr. Larry E. Williams
University of California
Kearney Ag Center
9240 S. Riverbend Avenue
Parlier, CA 93648

Dear Dr. Williams:

This is to formally notify you that you have been selected as a recipient of our Centers of Excellence Award. This award entitles you to a credit of $1,390.00 against the suggested retail price of $4,290.00 for a Scheduler™ Plant Stress Monitor. Please submit a purchase order as soon as possible as this award will be valid only until December 31, 1987. Thank you for your interest in this product.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

Scneaver™

Plant Stress Monitor

Centers of Excellence Award

This certifies that University of California - Kearney Ag Center **has been designated as a Center of Excellence, dedicated to quality research and/or teaching related to the Application, Methodology and use of instrumentation to properly manage plant stress.**

Date December 1, 1987 **Signed** Bronson Gardner

Bronson Gardner, Ph.D.
Product Technical Manager
Standard Oil Engineered Materials

A unit of the original Standard Oil Company founded in Cleveland, Ohio in 1870.

© GOES 462-1/2

LITHO IN U.S.A.

Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

December 3, 1987

Dr. Robert Edling
Louisiana Experiment Station
Agriculture Engineering Building
Baton Rouge, LA 70803-4505

Dear Robert:

Thank you for your description of next year's data. I can tentatively agree to the loan. By next January, it should be possible to fully commit. I can see no problems, however.

Enclosed is our standard research agreement. The only part usually questioned is the phrase "confidential." The only information we would like to see remain unpublished is the exact baseline for the crop in question. Since you may want to publish results of index values versus some other parameter, it may become necessary for you to know the baseline I develop. The agreement says you will not publish (or give out) our baselines without our consent.

The Scheduler^{R} Plant Stress Monitor will measure surface temperatures +/- 60^{o} C of the internal temperature of the Scheduler. The air temperature sensor will not respond accurately below 0^{o} C. The accuracy of the humidity sensor is unknown below 5^{o} C. I am looking forward to working with you. If you have any publications on how to grow strawberries, descriptions of the life cycle of the crop, management practices to problems, I would appreciate them. Thank you.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

RESEARCH AGREEMENT

THIS AGREEMENT, effective this _____ day of _____, 198__, between Standard Oil Engineered Materials Company, a Corporation of the State of New York, referred to hereinafter as "STANDARD OIL", and _____ to be referred to hereinafter as "COOPERATOR". STANDARD OIL and the COOPERATOR will be studying and demonstrating the use of STANDARD OIL's proprietary instrument. In consideration of the rights and obligations herein set forth below the parties agree as follows:

STANDARD OIL will provide COOPERATOR with the instrument for determining irrigation requirements for a test area. STANDARD OIL will maintain ownership of the instrument and COOPERATOR will return the instrument to STANDARD OIL at the completion of the program or upon receipt of written notice from STANDARD OIL. STANDARD OIL will instruct the COOPERATOR in the intended use of the instrument. The COOPERATOR will use reasonable care in handling and storage of the instrument which shall include adequate security. COOPERATOR will be responsible for using the instrument for collecting data. COOPERATOR will be responsible for maintaining records of irrigation and rainfall on the test area by location, date and time for purposes of result comparison. COOPERATOR will not tamper with the instrument. Cooperator agrees to provide a copy of all data relevant to the instrument to STANDARD OIL upon request.

STANDARD OIL will have reasonable access to the instrument during the program for calibration, maintenance, repair, data retrieval and the like during the term of the program. STANDARD OIL will not be liable for damages that may occur to the crops in the test area by following the instrument readings.

Information such as designs, data, drawings, know-how, observations, techniques, inventions and the like relating to the instrument shall be exclusive property of STANDARD OIL and all rights, title and interests shall reside with STANDARD OIL. All information provided by STANDARD OIL pursuant to this Agreement shall be treated as confidential information. The COOPERATOR agrees at all times that the COOPERATOR will make no disclosure of the confidential information to any third party unless expressly authorized in writing by STANDARD OIL to do so. Information, data, know-how, observations, techniques and the like not related to the instrument are not affected by this Agreement.

COOPERATOR agrees that all inventions, improvements and developments in the instrument conceived or developed as a result of COOPERATOR's participation with STANDARD OIL in this program, shall be disclosed to STANDARD OIL but otherwise shall be held confidential as indicated above, and COOPERATOR agrees, at STANDARD OIL's expense, to secure all intellectual property rights therein to STANDARD OIL by signing Patent applications, assignments and any other papers.

It is understood that in rendering COOPERATOR's services to STANDARD OIL, COOPERATOR will be acting as an independent contractor and not as STANDARD OIL's agent.

If COOPERATOR agrees to the above terms and conditions, please indicate your acceptance in the space provided below and return one copy of this to STANDARD OIL. This shall then constitute an agreement between us.

STANDARD OIL
ENGINEERED MATERIALS COMPANY

BY: _____

DATE: _____

COOPERATOR

BY: _____

DATE: _____

Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

December 8, 1987

Mr. Leland Hardy
USCS
201 East Indianola Ave
Suite 200
Phoenix, AZ 85012

Dear Leland:

Enclosed are seasonal graphs for a number of crops. I hope these provide you with the information you are looking for. Once a grower has obtained/produced a seasonal graph for his crop, he is in a strong position to begin benefiting from the Scheduler^{R} Plant Stress Monitor. In this area we have strength, since our baselines are formulated on the basis of seasonal data and evaluated with seasonal data. I would caution against using baselines developed with only a few days worth of data.

Sincerely,

Bronson Gardner

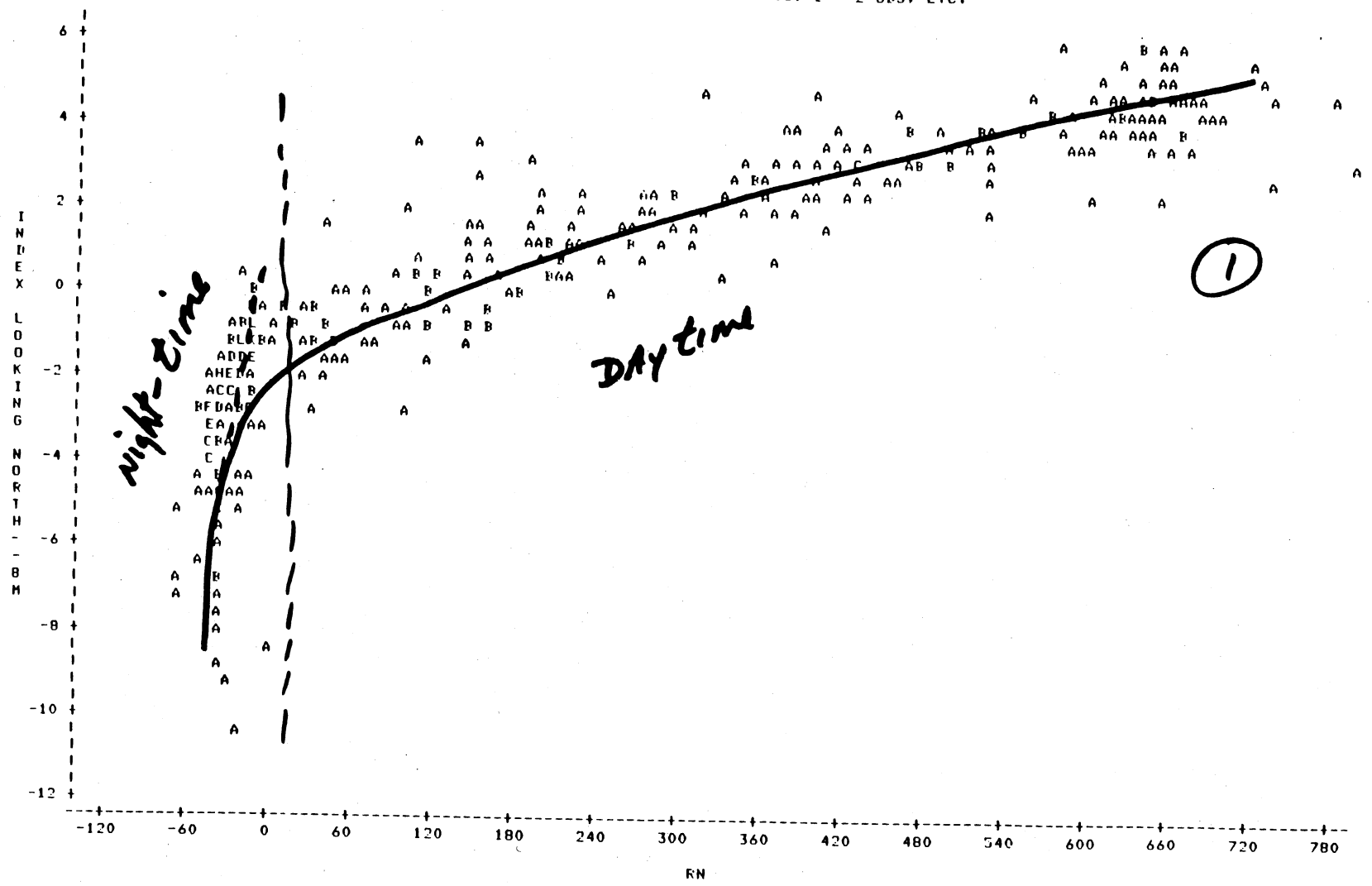
Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

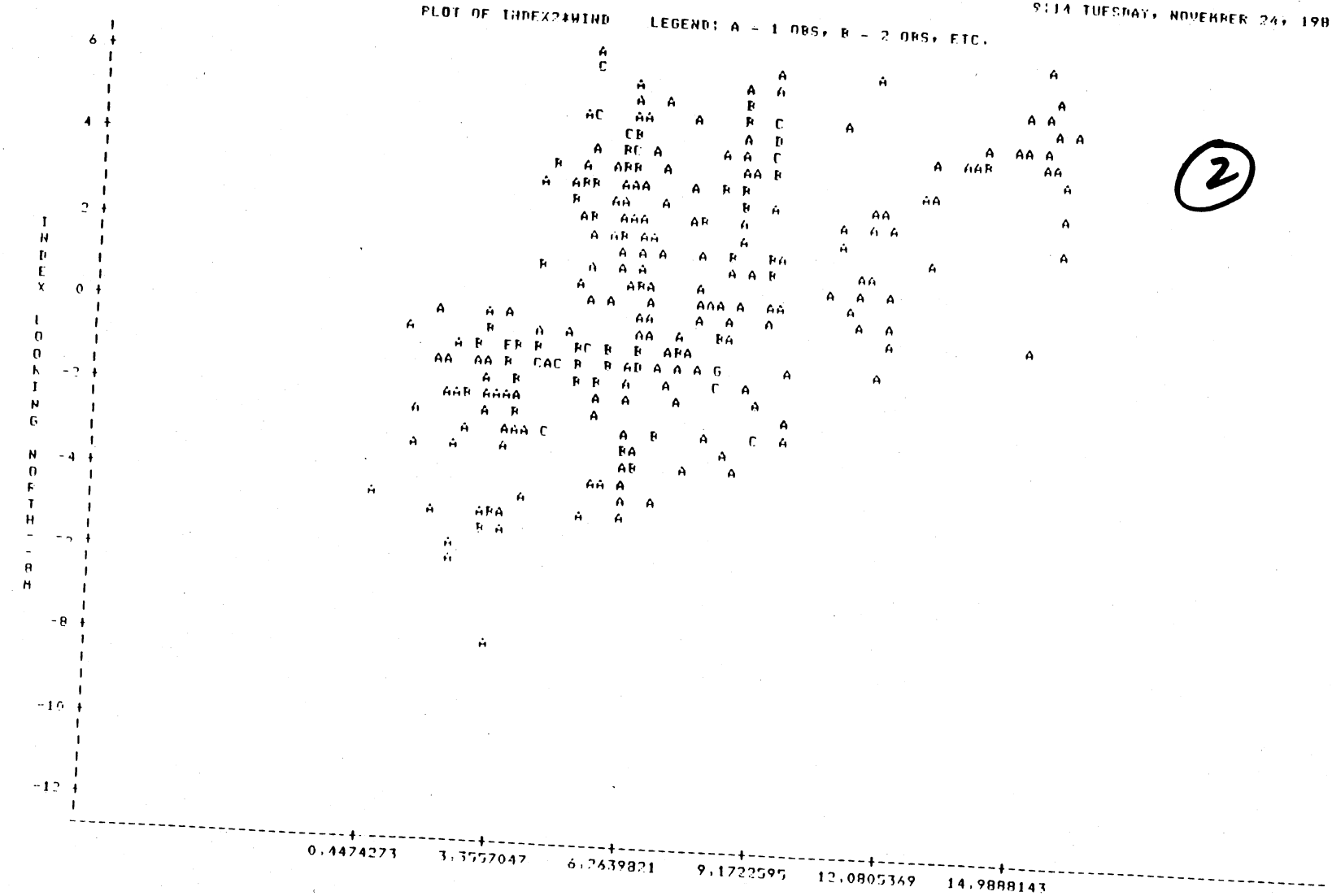
RELATIONSHIP BETWEEN POTATO INDEX AND NET RADIATION
AUGUST 13-AUGUST 23, 1987--ABERDEEN, IDAHO

10:43 MONDAY, NOVEMBER 23, 1987 1

PLOT OF INDEX2*RN LEGEND: A = 1 OBS, B = 2 OBS, ETC.



NOTE: 142 OBS HAD MISSING VALUES



(2)

NOTE: 213 OBS HAD MISSING VALUES

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: INDEX2 INDEX LOOKING NORTH--8M

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	2	2451.10862134	1225.55431067	994.19	0.0	0.859513	165.3444
ERROR	325	400.63359910	1.23271877		ROOT MSE		INDEX2 MEAN
CORRECTED TOTAL	327	2851.74222043			1.11027869		0.67149473

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
RN	1	2448.19797169	1986.02	0.0	1	1799.41735606	1459.71	0.0
WIND	1	2.91064964	2.36	0.1254	1	2.91064964	2.36	0.1254

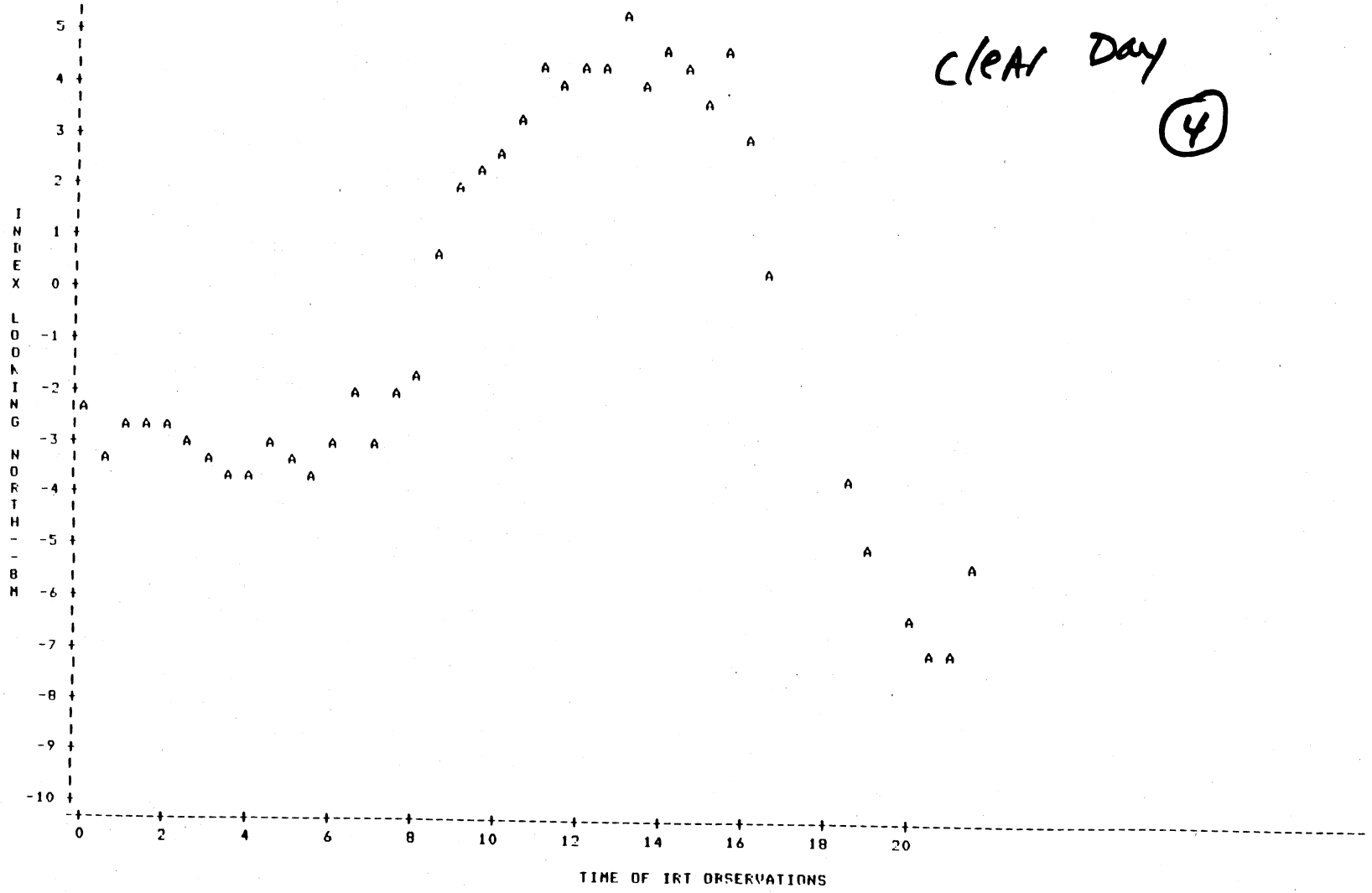
PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	-24.40155326	-41.02	0.0	0.59493962
RN	4.24438262	38.21	0.0	0.11109144
WIND	0.03385629	1.54	0.1254	0.02203314

(3)

DAILY POTATO INDEX PATTERN--AUGUST 16,1987
ABERDEEN, IDAHO--POTATOES

10:44 MONDAY, NOVEMBER 23, 1987 13

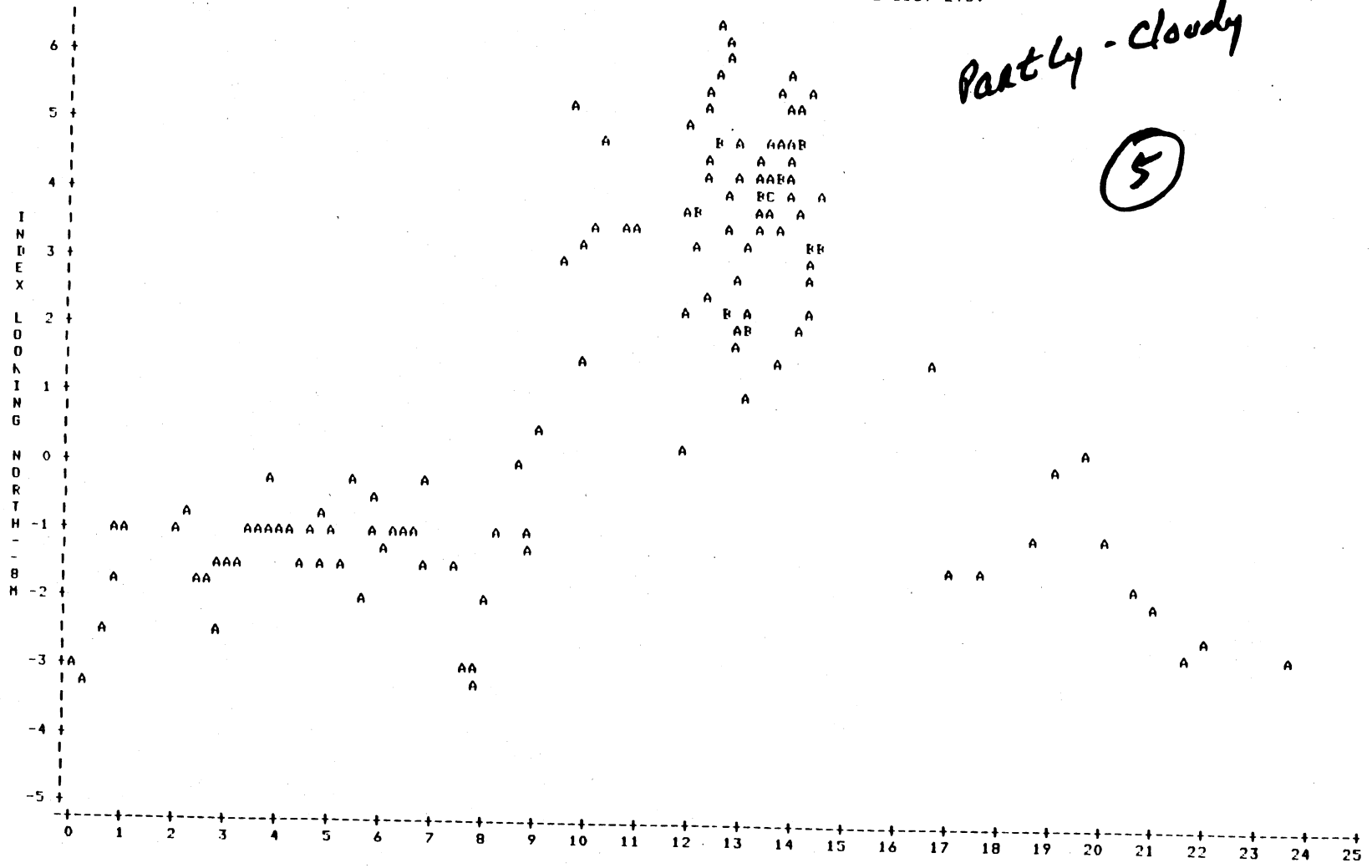
PLOT OF INDEX2*TIME LEGEND: A = 1 OBS, B = 2 OBS, ETC.



clear Day (4)

DAILY POTATO INDEX PATTERN--AUGUST 14,1987 10:44 MONDAY, NOVEMBER 23, 1987 7
ABERDEEN, IDAHO--POTATOES

PLOT OF INDEX2*TIME LEGEND: A = 1 OBS, B = 2 OBS, ETC.



Partly - Cloudy

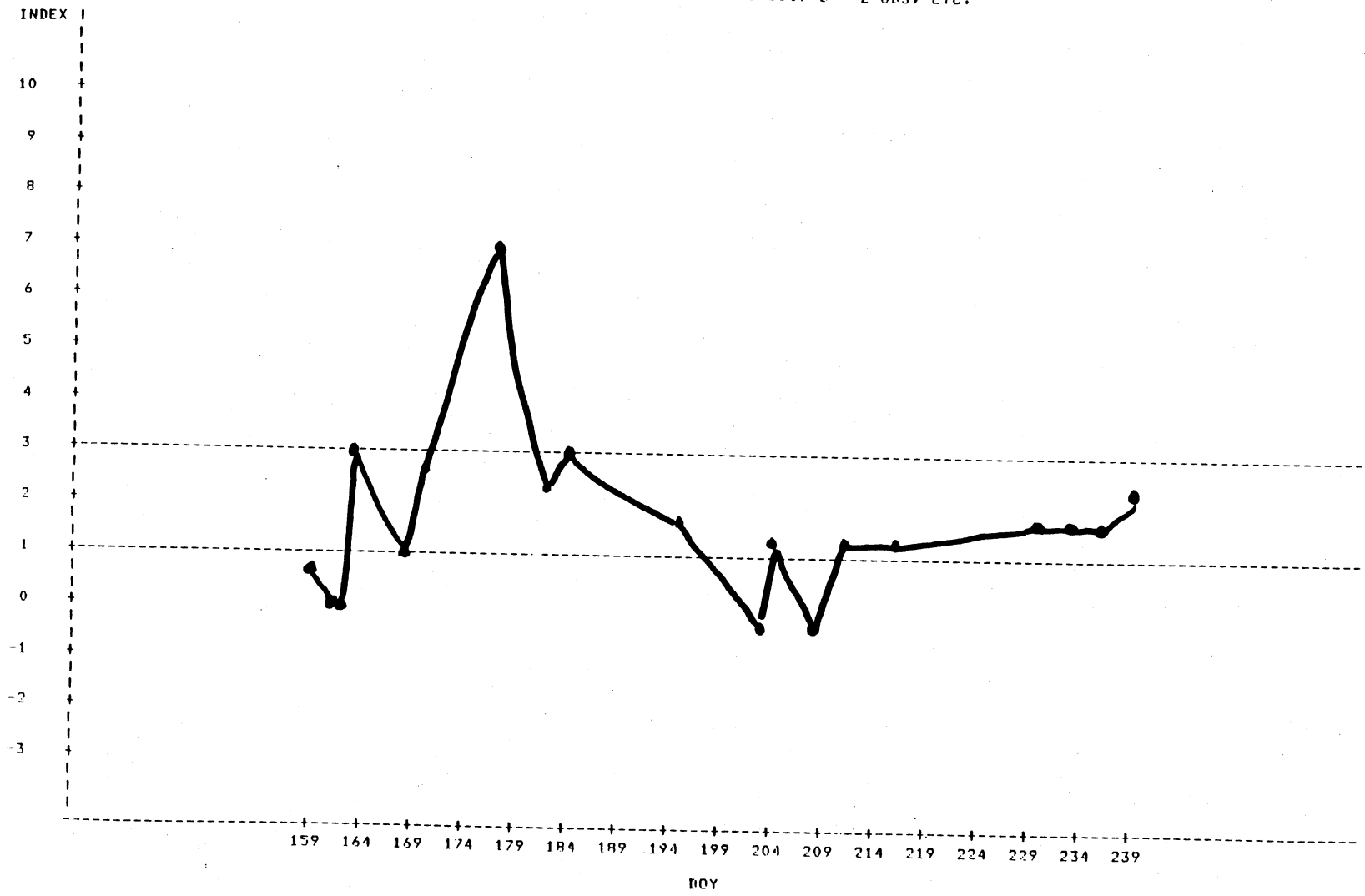
(5)

NOTE: 5 OBS HAD MISSING VALUES

DAILY MEAN INDEX VALUES FOR ALFALFA
CLINT SHOCK--1987

CROP=SEED.ALFALFA SEED YIELD (LBS/ACRE)=96.2

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

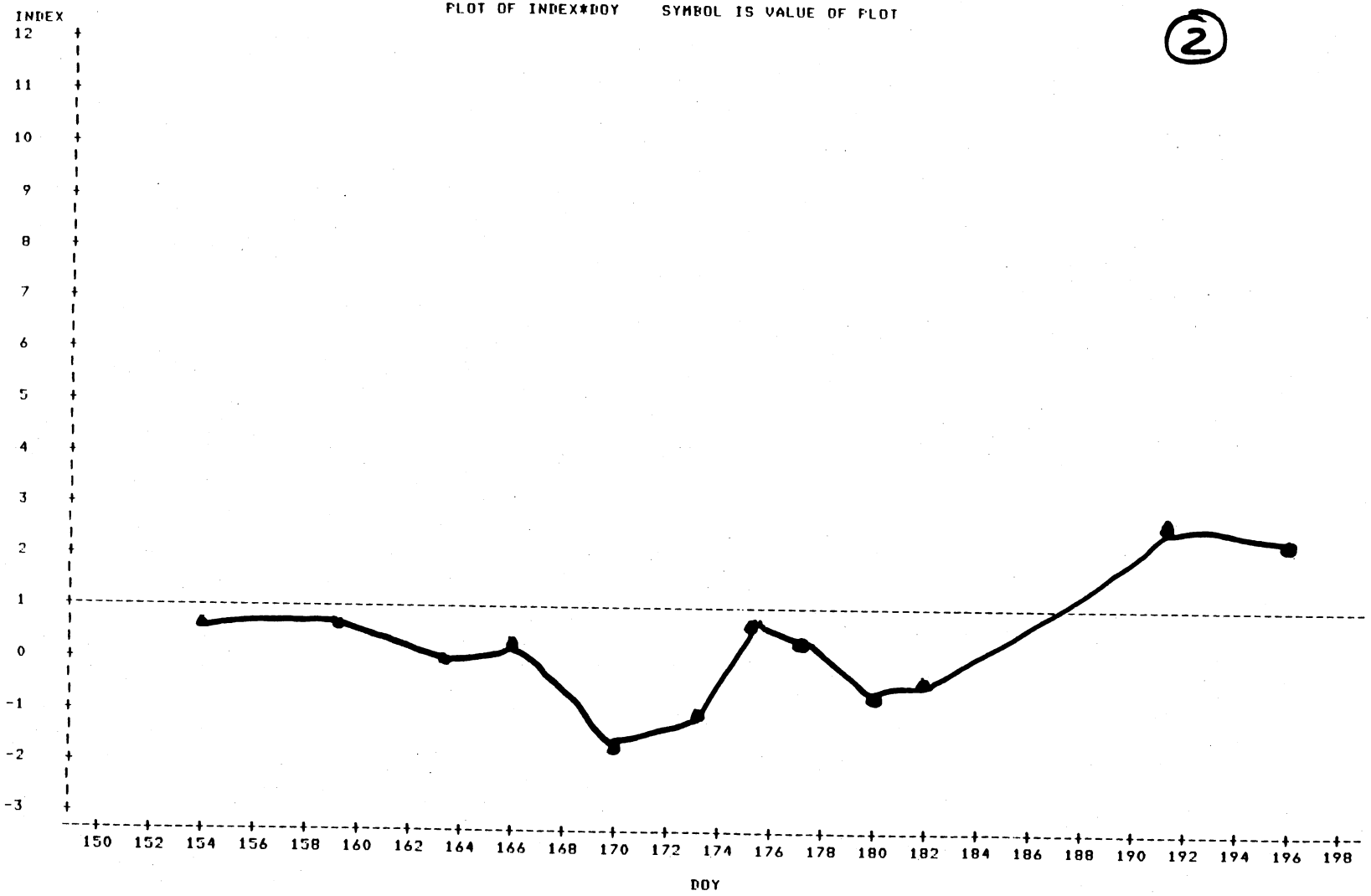


CANTALOUPE INDEX TRENDS --FRESNO,CALIF., 1987
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=1444 PLOT=blk

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(2)

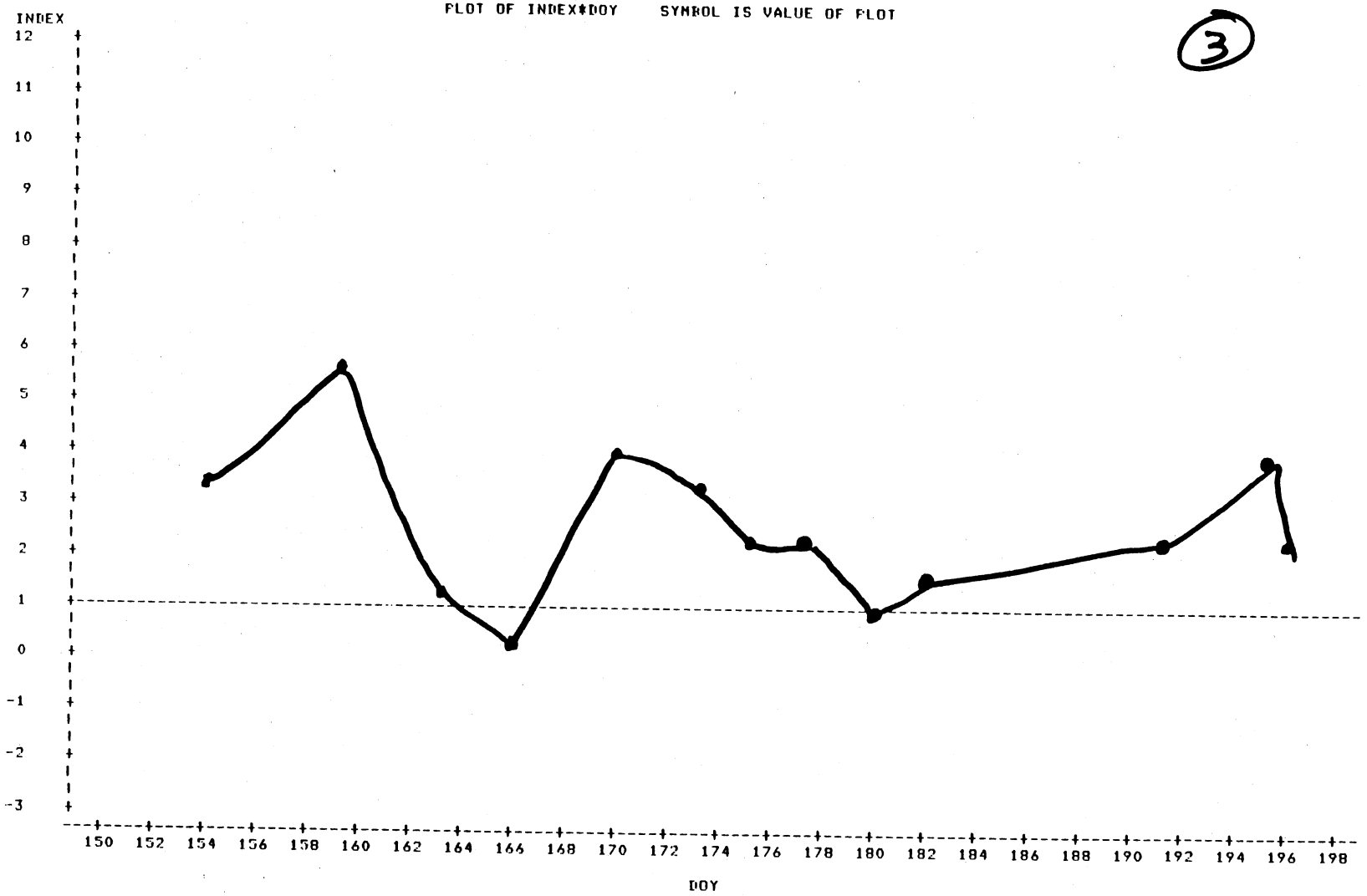


CANTALOUPE INDEX TRENDS --FRESNO,CALIF.,, 1987
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=758 PLOT=c6--A

PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(3)



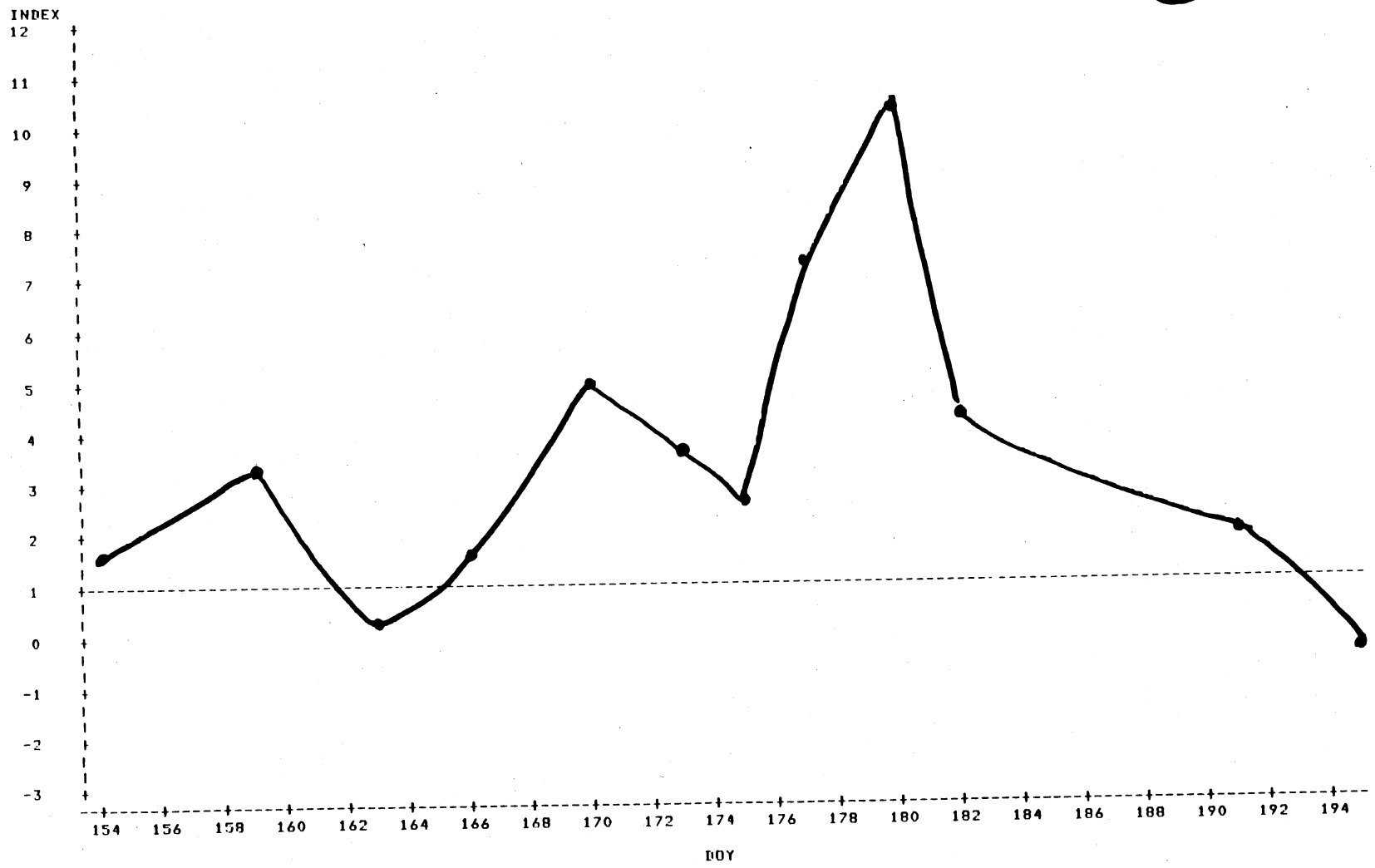
CANTALOUPES - FRESNO, 1987

CANTALOUPE ...
BOXES/ACRE = TOTAL BOXES OF 14,18 AND 23 MELONS/BOX
DATES OF MEASUREMENT: JUNE 3 - JULY 14, 1987

BOXES PER ACRE=348 PLOT=c12-A

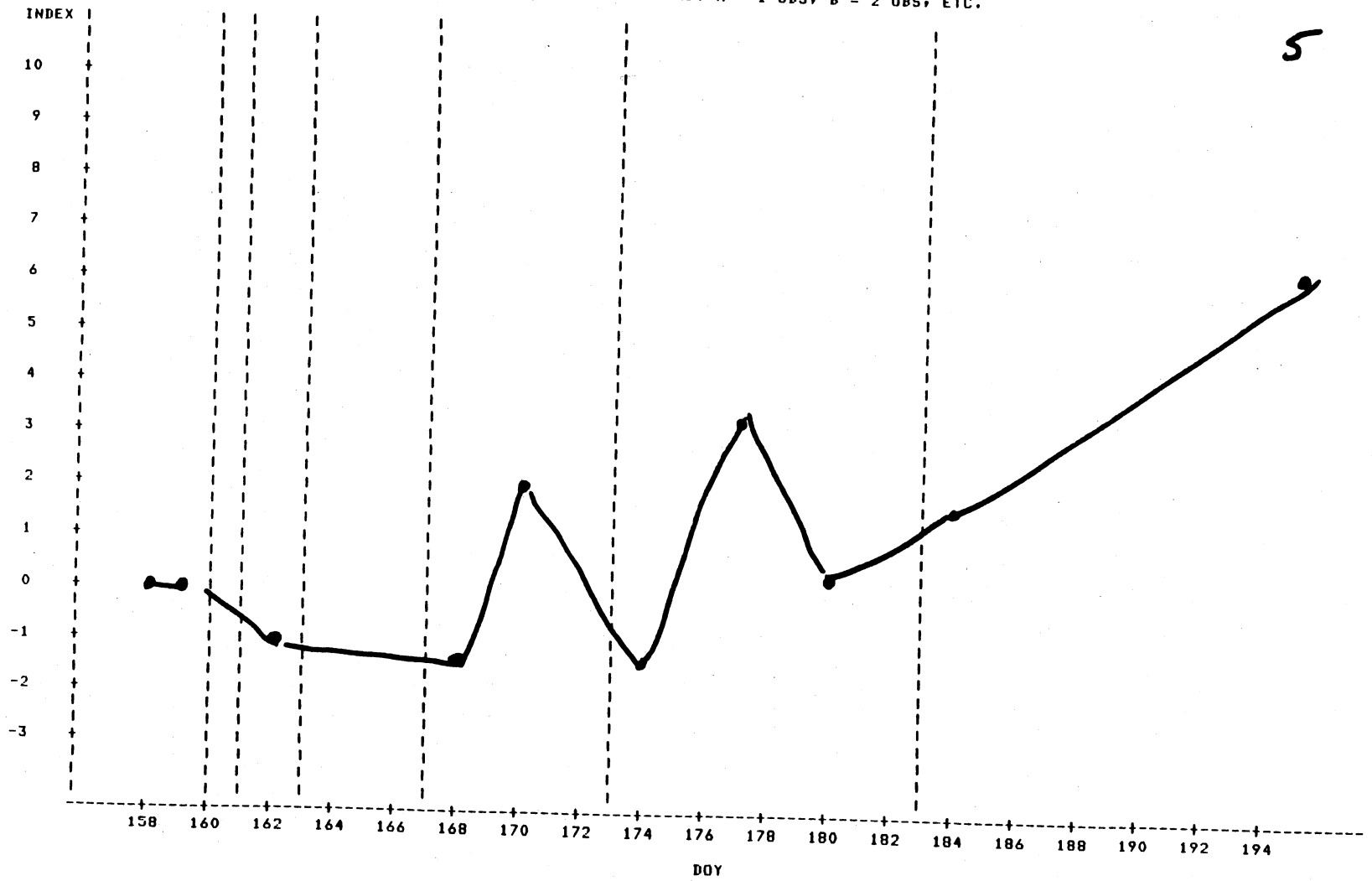
PLOT OF INDEX*DOY SYMBOL IS VALUE OF PLOT

(4)



BASELINE FOR SPEARMINT--CLINT SHOCK, 1987 DATA
YIELD=110-120 LBS OIL PER ACRE
VERTICAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

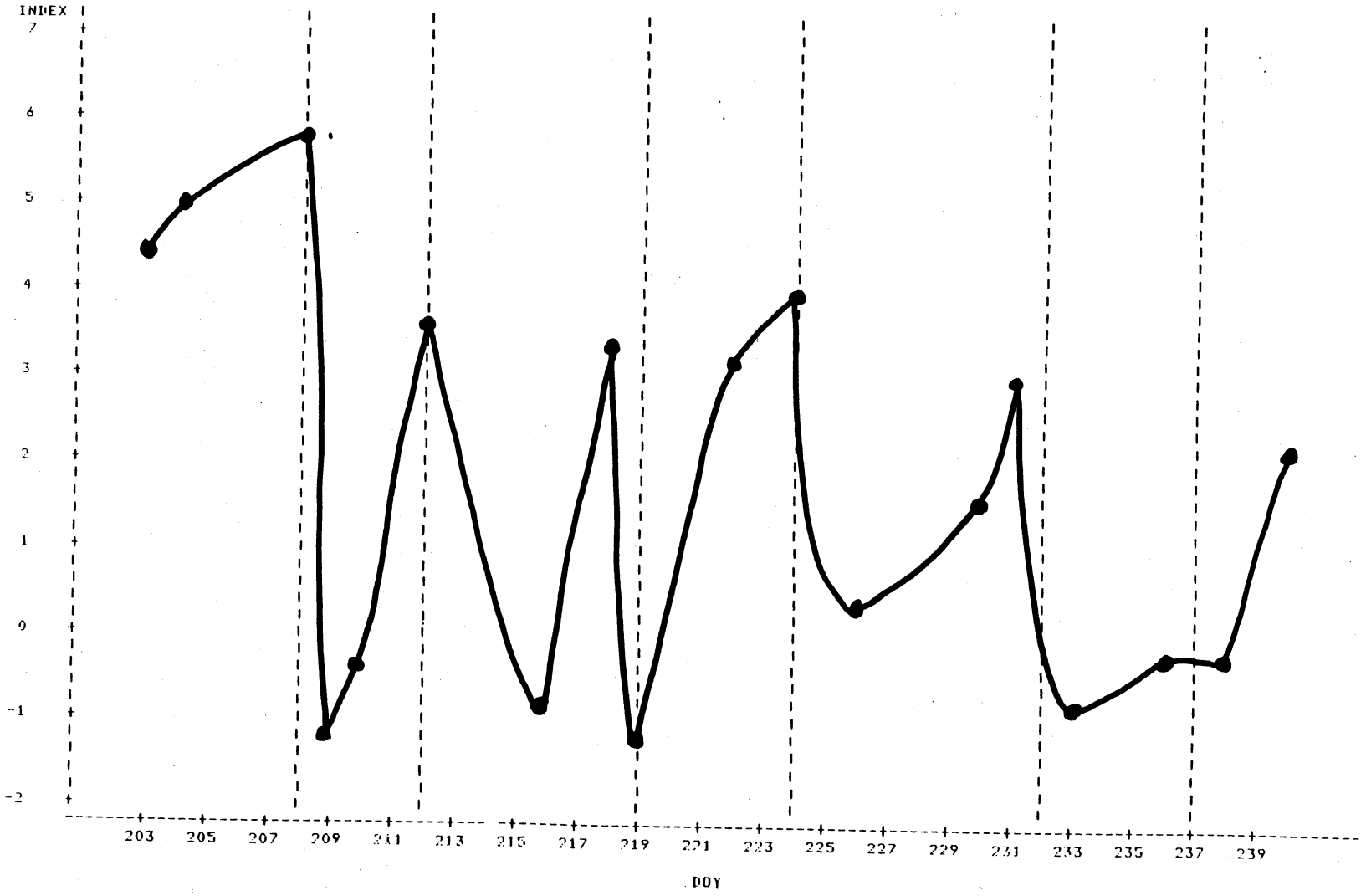
PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.



5

(6)

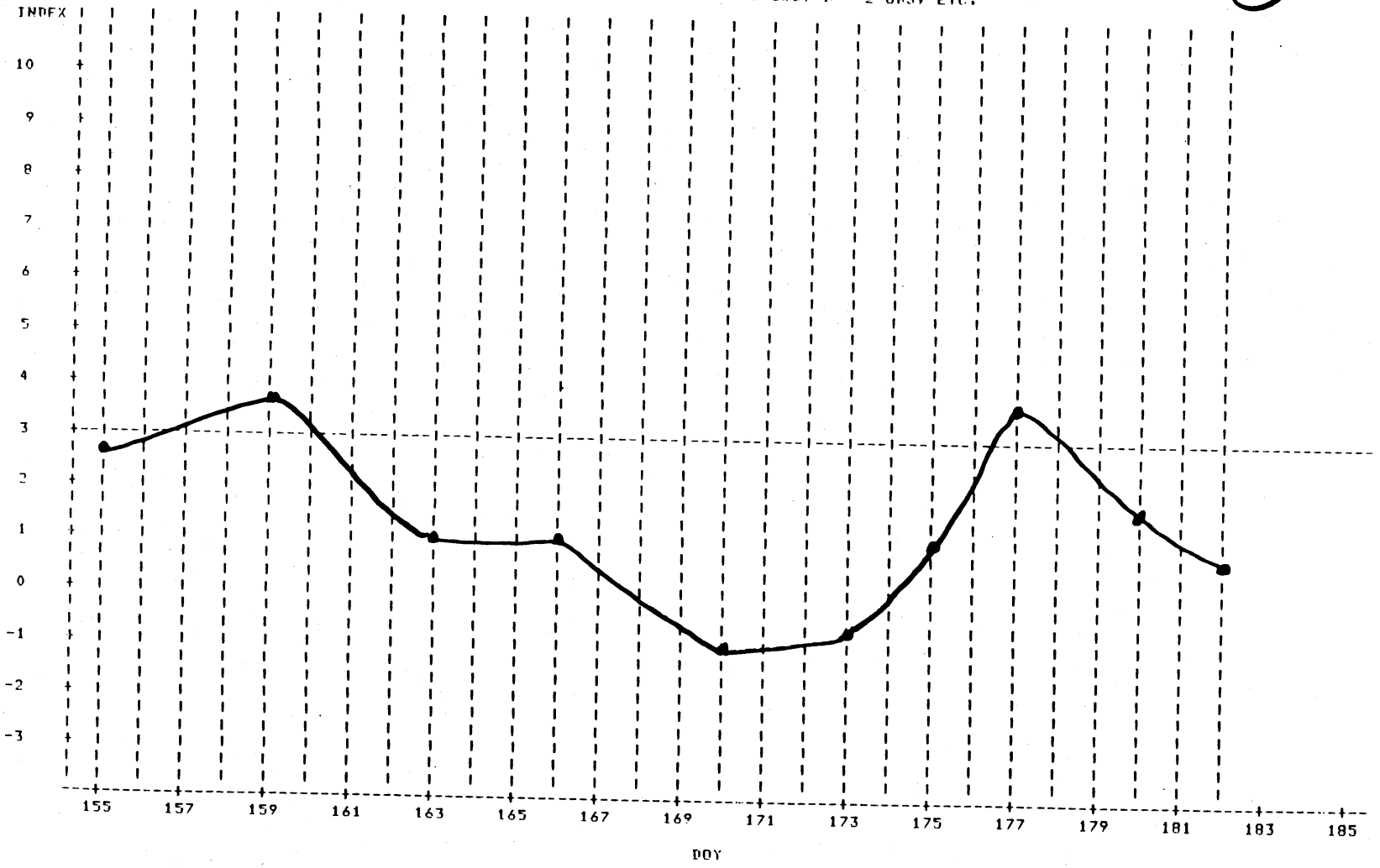
RASPBERRY STRESS INDEX PATTERNS: BYU, 1987
VERTICAL LINES INDICATE WHEN RAIN/IRRIGATION OCCURRED



WATERMELON DATA--CHARLIE KRAUTER, 1987
VERTICAL LINES REPRESENT IRRIGATION DATES
TREATMENT= REPLACEMENT ET
YIELD = 64,771 LBS/ACRE SUGAR CONTENT=10.68%

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

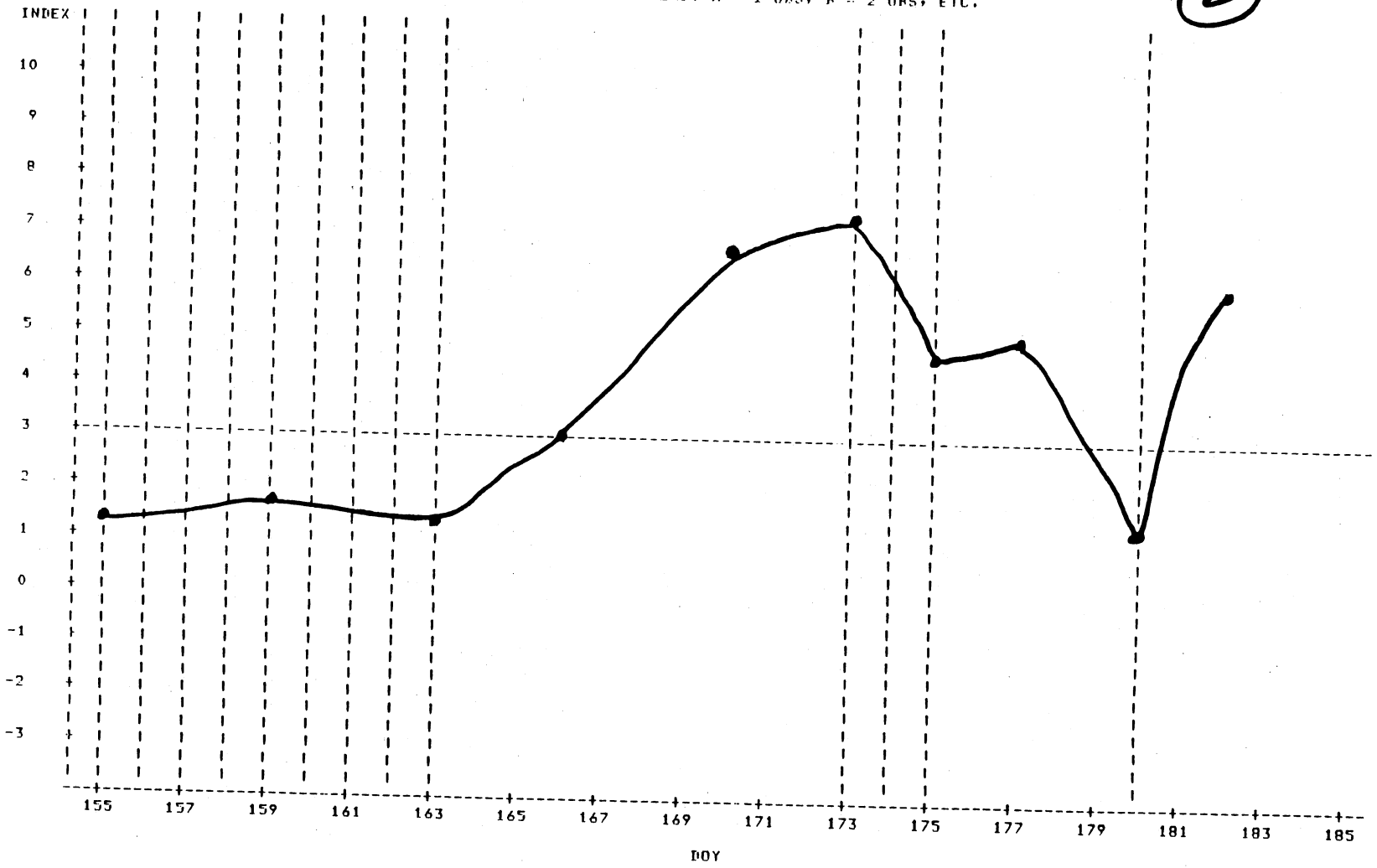
(1)



WATERMELON DATA--CHARLIE KRAUTER, 1987
VERTICAL LINES REPRESENT IRRIGATION DATES
TREATMENT- MEDIUM STRESS
YIELD= 19,306 LBS/ACRE SUGAR CONTENT=8.7%

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

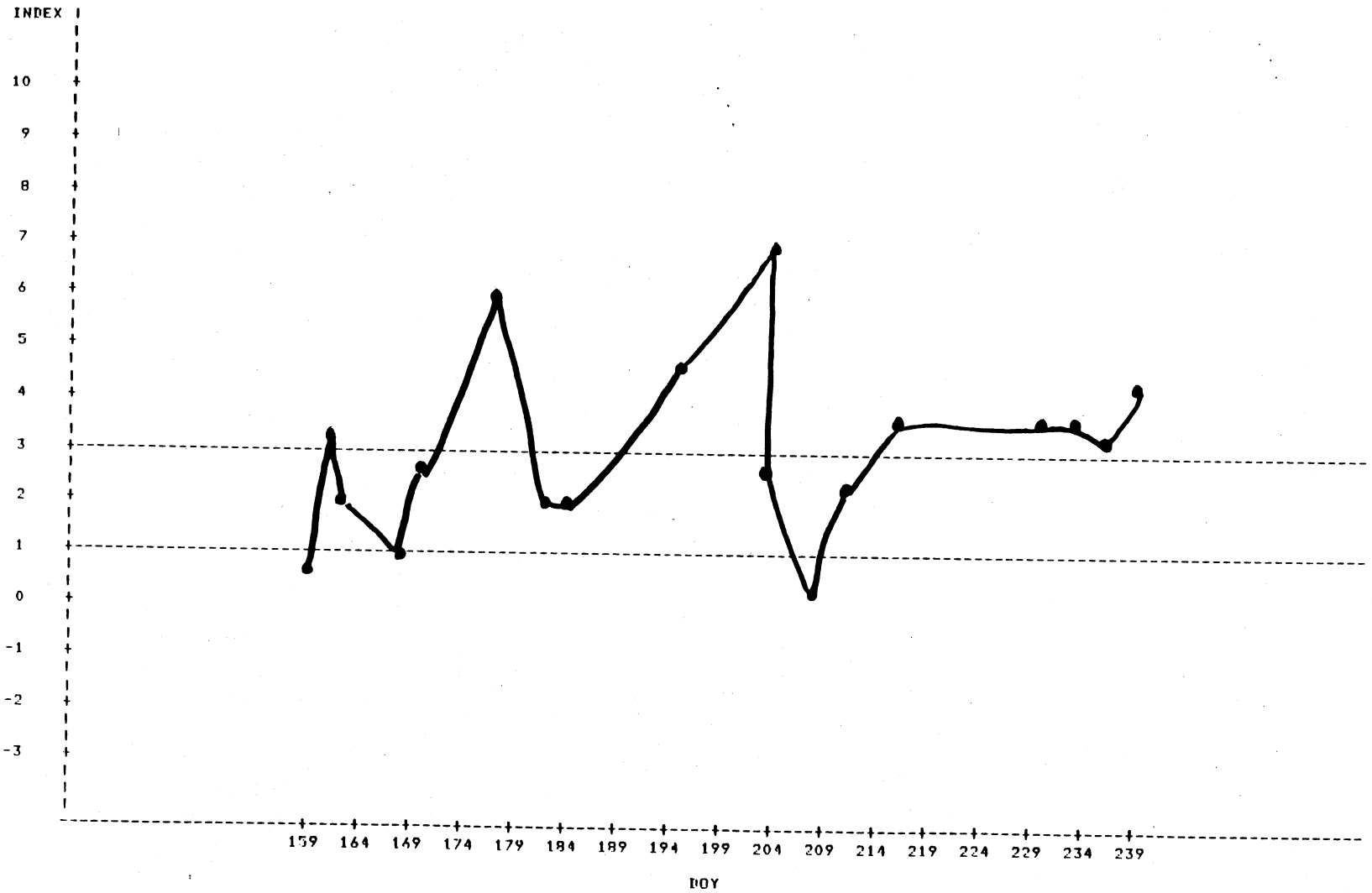
(2)



DAILY MEAN INDEX VALUES FOR ALFALFA
CLINT SHOCK--1987

CROP=SEED.ALFALFA SEED YIELD (LBS/ACRE)=502.4

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

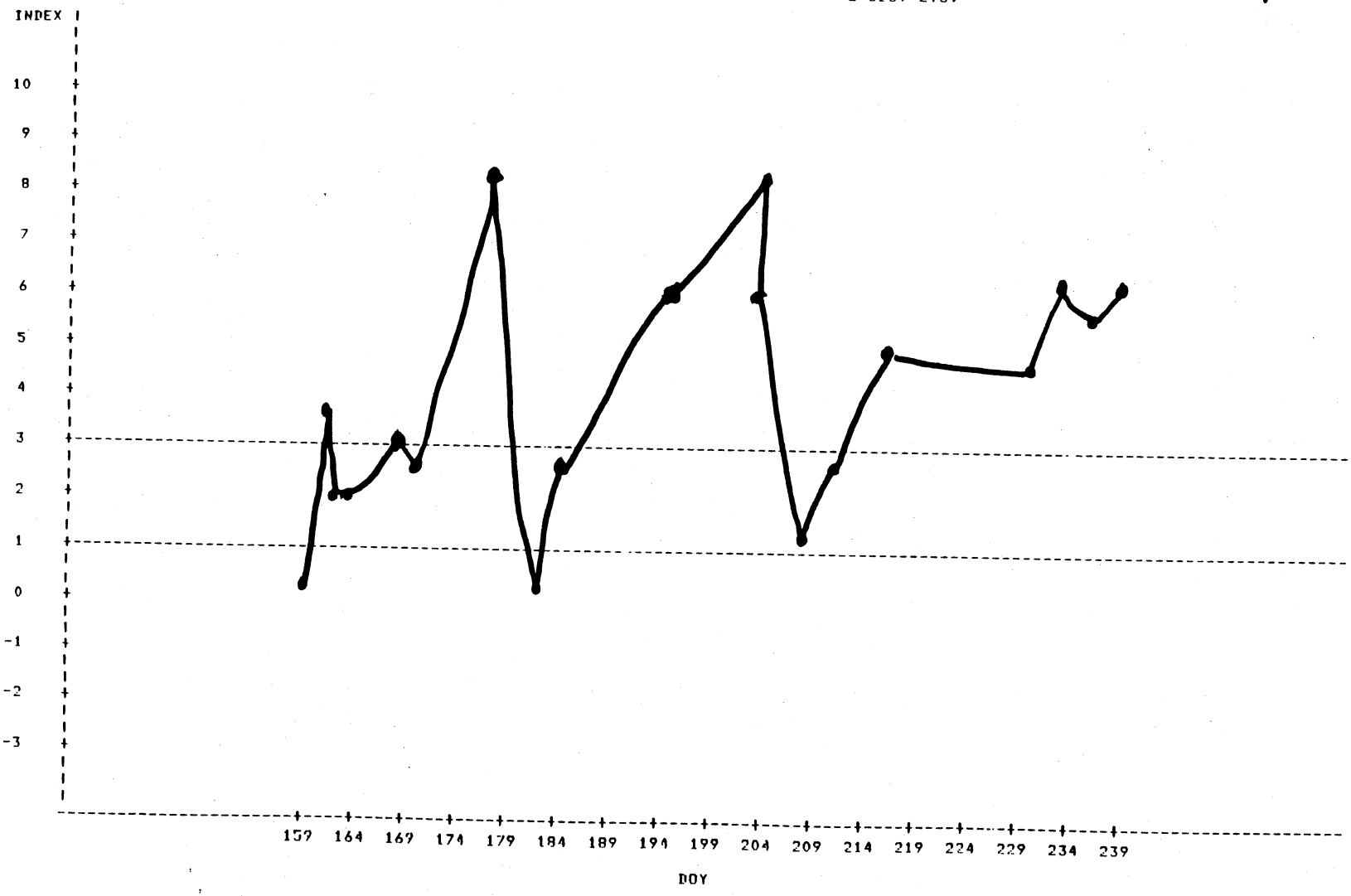


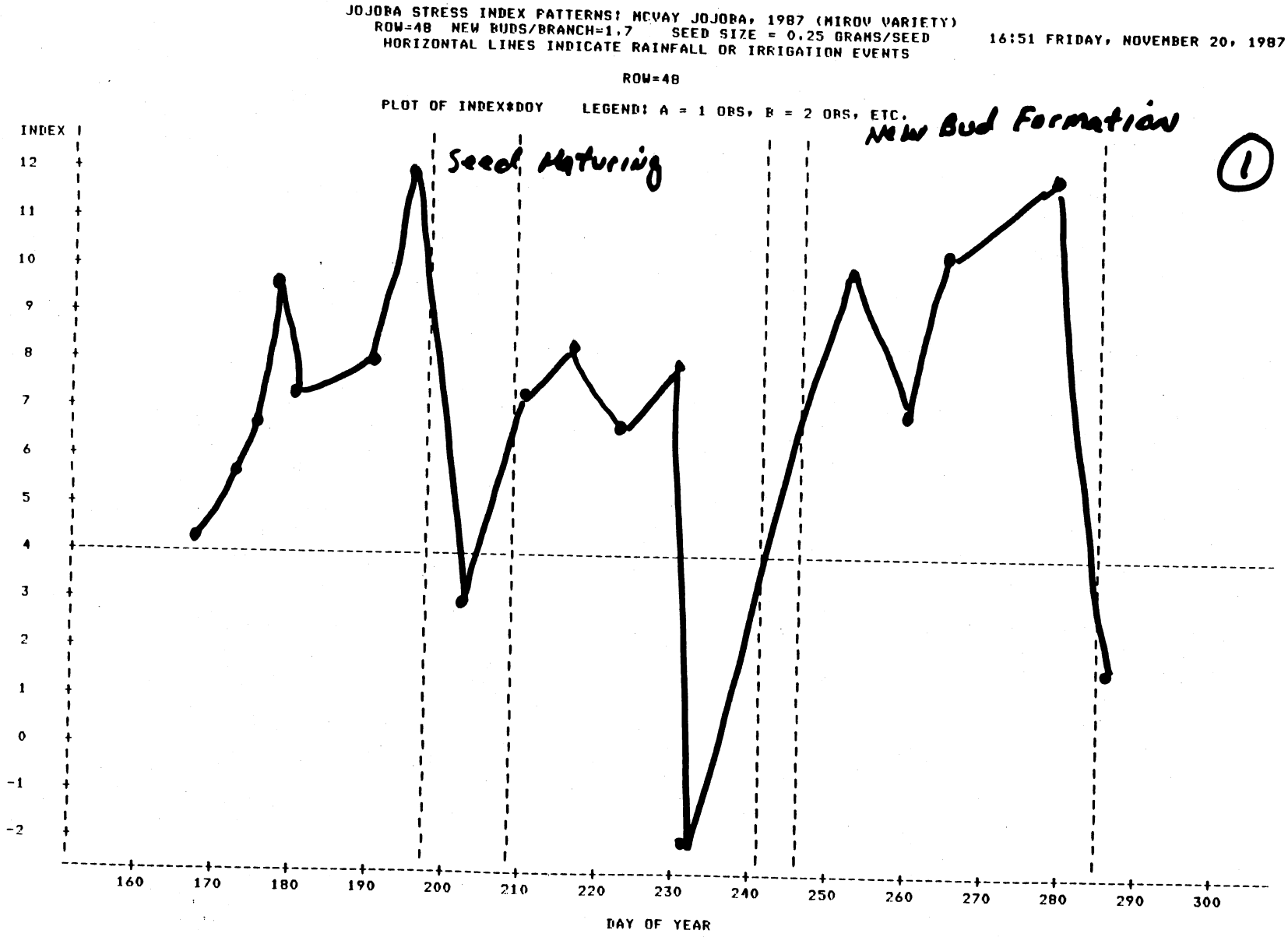
DAILY MEAN INDEX VALUES FOR ALFALFA
CLINT SHOCK--1987

CROP=SEED,ALFALFA SEED YIELD (LBS/ACRE)=835.1

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

4

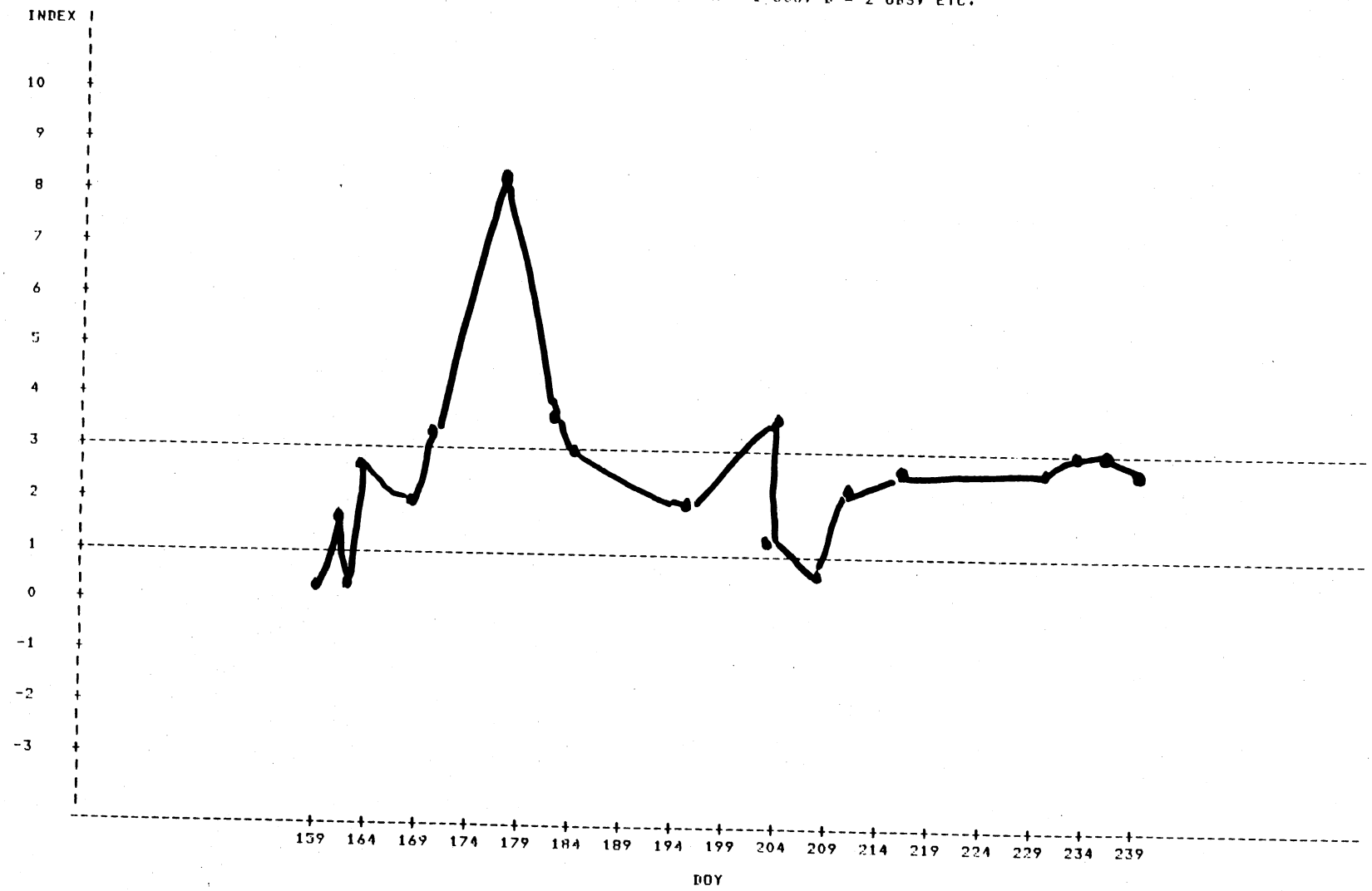



JOJOBA STRESS INDEX PATTERNS: MCVAY JOJOBA, 1987 (MIROV VARIETY)
ROW=48 NEW BUDS/BRANCH=1.7 SEED SIZE = 0.25 GRAMS/SEED
HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS
16:51 FRIDAY, NOVEMBER 20, 1987
ROW=48
PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.
Seed Maturing
New Bud Formation
(1)
INDEX
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
DAY OF YEAR

DAILY MEAN INDEX VALUES FOR ALFALFA
CLINT SHOCK--1987

CROP=SEED.ALFALFA SEED YIELD (LBS/ACRE)=285.3

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.



EMBER 20, 1987

JOJOBA STRESS INDEX PATTERNS! MCVAY JOJOBA, 1987 (HIROV VARIETY)
ROW=54 NEW BUDS/BRANCH=4.4 SEED SIZE = 0.75 Grams/acre

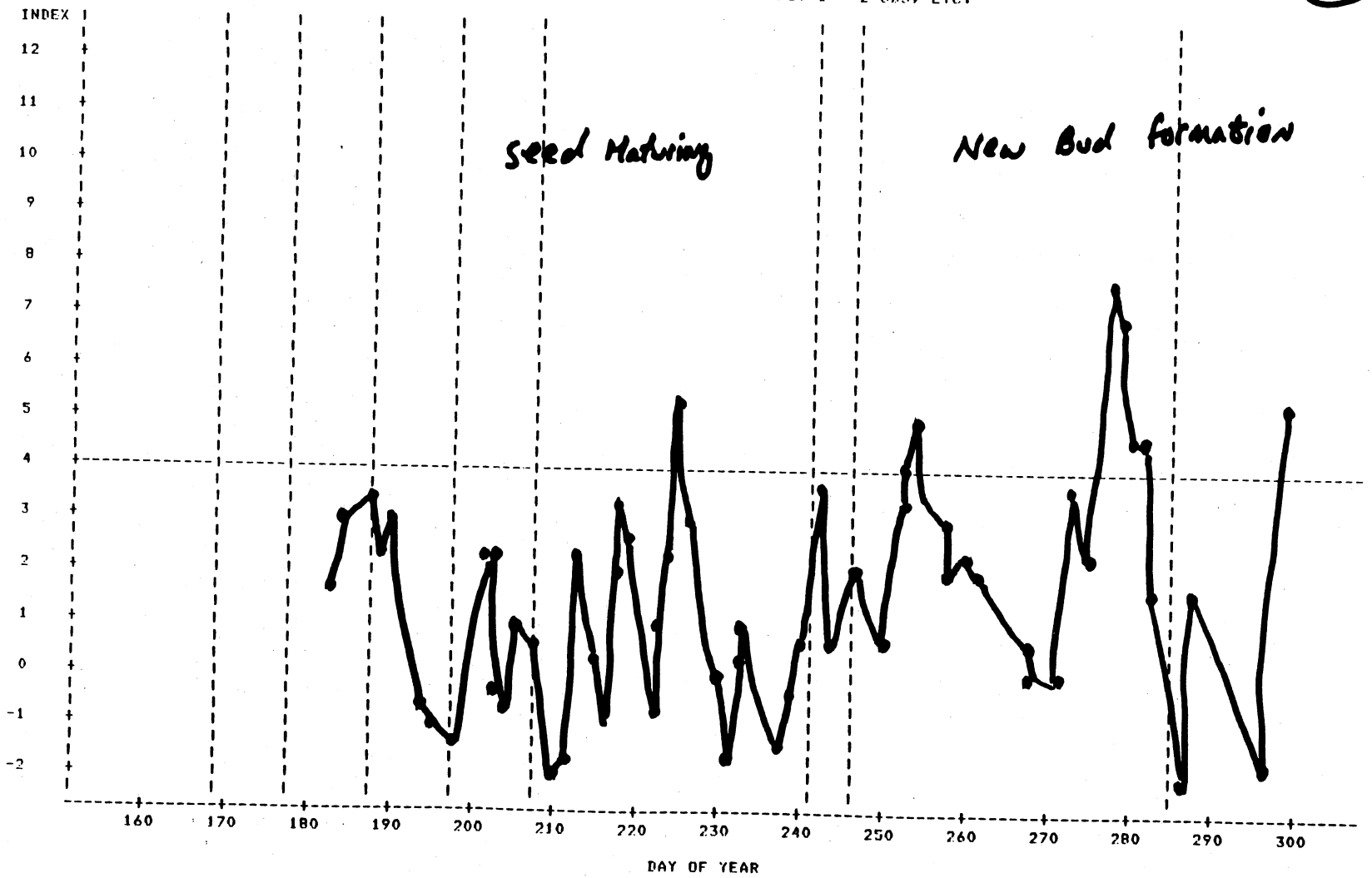
16:51 FRIDAY, NOV

HORIZONTAL LINES INDICATE RAINFALL OR IRRIGATION EVENTS

ROW=54

PLOT OF INDEX*DOY LEGEND: A = 1 OBS, B = 2 OBS, ETC.

(4)



B. Gardner

ABSTRACT FORM — AGRONOMY ABSTRACTS

American Society of Agronomy — Crop Science Society of America — Soil Science Society of America

Type one perfect copy following closely the directions below. Title-Summary no. C3-136

fold here only

↓ TYPE ABSTRACT HERE ↓

Potato Crop Water Stress and Tuber Quality.

C. C. SHOCK*, E. ELDREDGE, and B. GARDNER,
Oregon State Univ.

Russett Burbank potatoes were grown over a gradient of soil moisture conditions. Applied seasonal irrigation water ranged from 86 cm near the sprinkler line to 11 cm. Soil temperatures, soil water content, air temperature, air relative humidity, crop canopy temperature, wind speed, and solar radiation were determined. Crop water stress indices were highly correlated with soil moisture status. Crop water stress indices were more closely related to final tuber quality than to tuber yields. Percent number one tubers decreased and the percent number two tubers increased with observed CWSI. Tuber specific gravity decreased with higher CWSI values. Tuber sugar-end fry color reflectance decreased with increased CWSI. CWSI observations may be a rapid practical tool to check potato crop irrigation needs.

fold here only

Mailing Address of Corresponding Author:
Title and name
Department
University or other organization
Street or P.O. Box if needed
City, State, ZIP CODE

Dr. Clinton C. Shock, Superintendent
Malheur Experiment Station
Oregon State University
595 Onion Ave.
Ontario, OR 97914

DIRECTIONS:

1) List the Title-Summary number, e.g., A5-27, C3-77P, S4-65P, SS-5, as shown on the Title-Summary acknowledgment note.
2) Your author-prepared abstract will be photographed "as is" for offset printing, thus typing must be clean and with solid black characters. Abstracts which will not reproduce suitably will be retyped at ASA Headquarters, the corresponding author will be charged $25, and author proofing will not be possible due to time limitations. No editorial corrections will be made. Any part of the abstract not WITHIN the above boxed area is lost in reproduction. See reverse side for sample abstract. Try a practice abstract before making the final copy.
3) *Title and Authors*—Start the title flush left and below top line. Indent each succeeding line in the title-author listing to the fifth space. Capitalize only the first letter of each major word in the title. *Underline the title.* List the authors with the initials first. CAPITALIZE ALL LAST NAMES OF AUTHORS. If more than one author, add an asterisk * to name of person presenting paper. Institution(s) follow authors' names; use abbreviations as suggested on reverse side. Include location by city and state only when federal agency or commercial firm is the sole sponsor.
4) Do not leave a blank space between title-author listing and text. Type text as one paragraph, starting first line flush left.

(over)

May 1987

Standard Oil Engineered Materials

Company, Sensors Technologies,

Cochran Road, Solon OH 44139 1.11.1988.

Dear Sir,

This year a Scheduler made by Standard Oil Eng. Mat. Company has bought by University of Agricultural Sciences at Keszthely. In Hungary one of the most important problems is the drought. It is our duty to investigate irrigation technics and we hope that the Scheduler will help us. The R/D Consultant Model would be very useful for us, but we had not find it yet in our Scheduler. Is this model built in the instrument or we have to order it from the company ?

For the purpose of research work we need more information about the models built in the instrument. I should like to ask you to send me some references about the software used for constructing the Scheduler. I would be very glad to get some information about the sensors as well; rel. humidity, sun radiation e.t.c.

These kind s of information are very important for introdution of this instrument to scientific and farming usages in our country.

Thank you for your help.

Sincerely,

Dr. Angéla Anda

agrometeorologist

Address : Dr. Anda Angéla

Agrometeorological Res. Station

Keszthely P.O.Box 80.

H-8361 Hungary

MARK WOOD BSc AGRIC

P.O. BOX 45
MAZOWE
TEL: 543 MAZOWE

ZIMBABWE

April 19,1988

The Technical Manager

Standard Oil

Sensor Technologies

P.O. Box 391316 Solon

Ohio 44139

Dear Sir

as an agricultural Consultant in the Mazowe Valley in Zimbabwe, I have a considerable area of irrigated crops amongst my clients. I read about your SCHEDULER in the Feb 1988 Agribusiness Worldwide, and am interested in any aid to improving the performance of irrigation.

In order for me to justify to our government, that the foreign currency expenditure is justified however, I will require as much tecnical literature as possible to back up any claim as to its use in my area. If possible, relationships between observed and pre4dicted stresses in various crops would be particularly useful.

Thank you for your time and consideration

Yours faithfully

Mark Wood BSc.

Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

May 19, 1988

Mr. D. Small
Dara Research Institute
RMB 3010
Kyabram, Victoria 3620
Australia

Dear Mr. Small:

Mr. Tom Napier of Quarry Engineer Developments, indicated to me that your institute is interested in the irrigation of pasture. As you can tell from the enclosed literature, the Standard Oil Engineered Materials Company is now producing equipment which allows growers to directly measure the stress status of their crops, including pasture.

My questions relating to the use of the Scheduler^{R} Plant Stress Monitor on pasture in Australia are:

1) What type of irrigation systems are currently used to irrigate pasture (center pivots, sprinklers, flood...)

2) What percent of the pasture land is irrigated? How many total acres are being irrigated?

3) Are growers experiencing any problems with irrigation that would cause them to be interested in a stress monitoring tool? For example, are water supplies becoming scarce, expensive, or subject to government regulations? If growers could directly measure the stress status of vegetation, how would they benfit from this knowledge?

Currently, we are not conducting any research in Australia. If the situation warrants it, we will consider placing an instrument on loan to an interested researcher.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

Enclosures

Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

July 11, 1988

Dr. Gideon Oron
Ben-Gurion University of the Negev
The Jacob Blaustein Institute
Sede Boger Cempus
Israel 84993

Dear Dr. Oron:

Thank you for your interest in the Scheduler^{R} Plant Stress Monitor. I appreciate the opportunity to conduct research at your institute. It is true that Dr. Krauter at CSUF, Fresno has had an important role in developing some of the baselines used in the Scheduler. It is also true that several dozen other univeristy, USDA, and private researchers have also contributed heavily toward the development of the Scheduler. In short, we are satisfied that the device is directly transferrable to Israel without additional developmental research.

I believe you will find that the Scheduler will provide you with very useful information in your current field experiments.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

Phone Nos. 204 0553/204 6728
204 9521
Telex: C/o 011-6028 LMWL IN
Telegrams: JIJICOT

MAHALAKSHMI COTTON CO.

Jiji House, 3rd Floor, 15, Raveline Street, Post Box No. 1875, Bombay 400 001

No.1246/88-89 July 27, 1988

Mr. Bronson Gardner
Product Technical Manager
Standard Oil Engineered Materials Company
Sensor Technologies
P O Box 391316
6180 Cochron Road
Solon, Ohio 44139

Dear Mr. Gardner,

I acknowledge receipt of your letter dated July 22, 1988 alongwith enclosures. I am passing on same to my agents for a study.

Meantime, please provide me a copy of the training manual. As I understand, this is being used in various projects including Golf grounds etc. Can you indicate me few other projects where they use this unit besides cotton ?. Also provide me with pamphlets releating to other uses. Can you indicate the price?.

I shall write to you again as soon as my agents reply me.

Thanking you,

Regards,

Yours sincerely,

(JAYARAM MANI)

Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

August 16, 1988

Mr. Malcolm S. Allen
Riverina-Murray Institute of Higher Education
Ron Potter Centre
P. O. Box 588
Wagga wagga, NSW 2650
Australia

Dear Mr. Allen:

Thank you for your letter of August 8, 1988. We are always encouraged to hear of those interested in our innovative irrigation scheduling device, the Scheduler^{R} Plant Stress Monitor. Enclosed please find information on both the R&D and Production models, plus brochures and general information on the product.

We do have a distributor in Australia, Mr. Tom Napier, Savage Farming, P. O. Box 501, Victoria Valley, Victoria 3294, Telephone (055) 74 9232 or (008) 03 3831, Fax (055) 74 9214. Please contact him for demonstration and for helpful information.

Sincerely,

Bronson Gardner/lb

Bronson R. Gardner, Ph.D.
Product Technical Manager

cc: T. Napier

RIVERINA-MURRAY INSTITUTE OF HIGHER EDUCATION

Ron Potter Centre
PO Box 588
WAGGA WAGGA. NSW 2650
Australia

August 8, 1988

Dr Bronson Gardner
Standard Oil
Engineered Materials Company
PO Box 391316
6180 Cochran Road
SOLON. OH 44139
USA

Dear Dr Gardner,

During a visit to the USA in June to speak at the American Society for Enology and Viticulture meeting in Reno, I visited Sterling vineyards in California and had opportunity to speak with Dr Dan Roberts, their viticulturist. Dan spoke very highly of your "Scheduler" plant stress monitor and demonstrated its capabilities to me. In the brief opportunity that I had to handle the instrument, it was certainly most impressive.

As Riverina-Murray Institute of Higher Education presents a Viticulture course, the only Viticulture course in Australia, I and other staff here would be very interested to learn more about its capabilities. It would seem that in our climate, with an almost inevitable need for irrigation, the plant stress monitor could have tremendous potential, and be an instrument of which our students should be aware. Yet, as far as we can tell, the instrument is not yet in use in this country.

Dan Roberts indicated that two models of the "Scheduler" are available, with the "consultants" model having the most flexibility. Information about these two models would be useful, since our interest focusses not only on its potential as a production tool, but also as a tool for viticultural research and a monitor that may be suited to, or adaptable to, the many differing viticultural areas in this country.

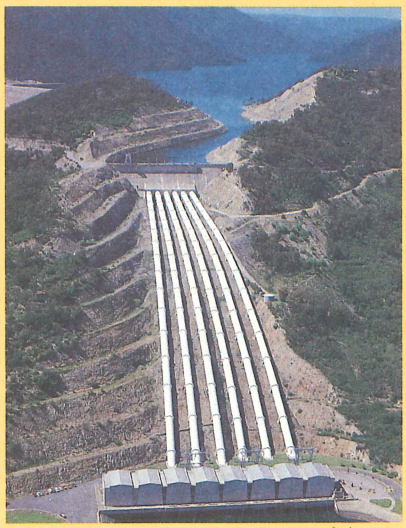
I look forward with great interest to hearing from you.

Yours sincerely,

Malcolm S. Allen

BY AIR MAIL PAR AVION

AEROGRAMME



Tumut 3 Power Station, Snowy Mountains Scheme, south-eastern New South Wales

WAGGA D.P.O. 5 9 AUG 1988 N.S.W. 2650

CHECK ADDRESS IF INCOMPLETE ADVISE WRITER

Nomad

TO Dr Bronson Gardner

Standard Oil, Engineered Materials Company

PO Box 3913160

6180 Cochran Road

COUNTRY OF DESTINATION SOLON, OH 44139. USA

SENDER'S NAME AND ADDRESS

SCHOOL OF AGRICULTURE

Dr M.S. Allen

Ron Potter Centre

RMIHE

PO Box 588

WAGGA WAGGA. NSW 2650

Australia

POSTCODE

FOLD SIDE FLAPS FIRST

FOLD SIDE FLAPS FIRST

TO OPEN SLIT HERE FIRST

DO NOT WRITE BEYOND THIS LINE

HONZAWA COMPANY, LTD.
16-21 KOAMICHO NIHONBASHI CHUO-KU TOKYO 103 JAPAN
TELEPHONE ; 03(664)6331

Telex 02522801 HOZACO Fax 03-667-2260

Bronson
I've sent a
copy by mail
today. 8/24/88
J.

August 23, 1988

Mr. Bronson R. Gardner, Ph.D., Product Technical Manager
Standard Oil Engineered Materials Company
Sensor Technologies
6180 Cochran Road, P.O.Box 391316, Solon, Ohio 44139, U.S.A.

Copy to Mrs. Lynn Bucknell, Sr. Sales Correspondent

Dear Dr. Gardner:

We received your fax of August 19, 1988 with many thanks.
But unfortunately, there are mutilations in some parts of your letter, though we can almost read them.
Kindly send us a copy of your letter for confirmation.

In the meantime, we are now continueing tests of the ST 27 Turf Monitor at several areas of a golf course and discussing on many items with people concerned.
As we guess that there are many primitive questions on operation of the ST 27 Turf Monitor, your kind explanations are highly appreciated.

Yours faithfully,

S.Suzuki, Manager of Overseas Trade Dept.

Standard Oil
Engineered Materials Company
Sensor Technologies
P.O. Box 391316
6180 Cochran Road
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

August 29, 1988

Mr. Jayaram Mani
Mahalakshmi Cotton Co.
P. O. Box 1875
Bombay 400 001
India

Dear Mr. Mani:

Thank you for your interest in the Scheduler^{R} Plant Stress Monitor. It is currently being used on many crops including alfalfa, cotton, beans, wheat, tomatoes, almonds, and sorghum. Our distributor in India is Mr. Satish Aneja, Elron Instrument company, B2, Satkar Bldg., 79-80, Nehru Place, New Delhi 110 019, India, Telex 031-71261 RAJ IN. By copy of this letter I am asking Mr. Aneja to contact you regarding price of unit.

Enclosed is a copy of our current training manual. We have learned a great deal this year and will probably update it sometime soon.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

enclosure

Standard Oil
Engineered Materials Company
Sensor Technologies
6180 Cochran Road
P.O. Box 391316
Solon, Ohio 44139
216 349-6881

STANDARD OIL
ENGINEERED MATERIALS
SENSOR TECHNOLOGIES

August 29, 1988

Mr. Malcolm S. Allen
Riverina-Murray Institute of Higher Education
Ron Potter Centre
P. O. Box 588
Wagga Wagga, NSW 2650
Australia

Dear Mr. Allen:

Thank you for your interest in the Scheduler^{R} Plant Stress Monitor. It is proving itself to be a valuable research tool in viticulture and other agronomic areas. The R&D/Consultant model is the preferred model for resarch. It provides the following:

- 240 memory locations (called fields)
- For each memory location:
  - Date and time
  - Averages for air temperature, crop temperature, humitity, sunlight intensity, and stress index (based on up to 999 samples)
  - Standard deviation of crop temperature
  - Number of samples taken

Enclosed is some technical information. If I can answer any further questions, do not hesitate to contact me. I am very anxious to see the Scheduler become part of a quality research program in Australia.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb
Enclosures

Bronson R.Gardner, Ph.D.

Product Technical Manager of

Standard Oil Materials Company

November 30 1988.

Dear Dr. Gardner,

Thank you for your letter of 15 November with the Technical Manual and other specification sheets on Scheduler. Your help arrived very quickly to our great delight.

Excuse me if my English offended against good manners. It was not intended !

Thank you for your kindness and help.

Sincerely,

Dr. Angéla Anda

Address : Dr. Angéla Anda

Keszthely Balaton u. 10.

H - 8360 Hungary

CARBORUNDUM

The Carborundum Company
Sensor Technologies
6180 Cochran Road
P.O. Box 391316
Solon, Ohio 44139

Telephone: 216 349-6881
Fax: 216 349-6397

December 7, 1988

Dr. Marcel Fuchs
Volcani Institute of Agriculture Res.
P. O. Box 6
Bet-Dagan, Israel

Dear Dr. Fuchs:

Your recent talk at the Agronomy Meeting has generated significant interest within the group which produces the Scheduler^{R} Plant Stress Monitor. I would like to study your model results further. Have you published these results yet? If so, may I obtain a copy? If not, are copies of the results you described available? Also, if possible, I would appreciate obtaining a copy of your model. This could help us in our efforts to evaluate the future direction of our infrared products.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

BRIGHAM YOUNG
UNIVERSITY

THE GLORY OF GOD
IS INTELLIGENCE

13 February 1989

Dr. Bronson Gardner
Standard Oil Engineered Materials Company
6180 Cochran Road
P.O. Box 391316
Solon, OH 44139

Re: Scheduler

Dear Bronson:

As I promised after our last telephone conversation, I am writing to inform you of my experience with the Scheduler in 1988.

I began an experiement with the following characteristics:

Objectives: Evaluate the effect of nitrogen fertilization levels and moisture stress (generated by differential irrigation levels) on yield and yield components of spring wheat. The cultivar used was Fieldwin.

Factors: Number of replications = 4; number of N levels = 4 (0, 80, 160, and 240 lb/ac); number of irrigation levels = 7. The latter was brought about by using a line-source sprinkler irrigation setup as described by R. J. Hanks.

Variables Measured: The measured variables were nitrate level in soils before application of nitrogen and at end of the season, nitrate levels in flag leaves of plants from each treatment (in fact each plot) at two stages of development (preboot and anthesis), grain yield (bu/ac), and the following yield components: number of heads (spikes) per unit area, number of spikelets per spike, number and position of barren spiklets per spike, kernel or grain weight, straw weight, and elemental analysis of the grain and straw (which included chaff).

To monitor the moisture stress situation I did two things: first, placed the neutron probe access tubes in plots treated with one N level (160 lb/ac N) and all 7 moisture levels in each of the four replications (this amounted to 28 plots out of the 112 in the experiment in which I measured soil moisture status a 9, 21, and 33-inch depths); second, I used the scheduler to determine plant and air temperatures, the air-plant temperature differentials, and the stress index for all 112 plots. These readings, both neutron probe and scheduler, were taken twice each week.

I have not completed analysis of the data, because of the lack of time, but the process of taking the Scheduler readings probably taught me more about how

DEPARTMENT OF AGRONOMY AND HORTICULTURE
275 WIDB
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH 84602
(801) 378-2760

plants respond to stress than all the textbooks or articles I have ever read. The impressive measurements were the air and plant temperatures and the differential that was evident as the plants became more and more subject to moisture stress and the hot, mid-summer temperatures. The average difference in early June seemed to be about $5^{o}C$, but later in the summer on the plots receiving little or no irrigation water, the differential was as much as $12^{o}C$. On those plots that received adequate irrigation water, the plants were invariably cooler than the surrounding air (which one would of course expect). I had had other experiences that told me there were large differences (in Arizona I could feel the difference in the well-watered cotton and the air temperature), but I had never experienced such vivid and instant display of each temperture before. I sometimes feel that, for a researcher, the most important thing gained from use of the Scheduler is the air-plant temperature differential. Its allows one to visualize very readily the differences he or she intuitively knew were there, but had never realized they were so striking.

I would like to continue using the Scheduler again this summer during the second year of the above study. If, after I have analyzed the data from the two years, I am satisfied that the Scheduler will be just as suitable as the neutron probe in evaluating plant stress and scheduling of irrigation, I may forget about using the neutron probe. Even though the new models of the probe are lighter than the old Nuclear Chicago probes, they are still coumbersome and collecting the data is very time consuming. I could collect the data from all 112 plots with the scheduler in the same amount of time it took me to collect the data from the 28 neutron probe access tubes--about 2 hours.

I am expecting that I will find time to analyze the data we collected before the end of the semester--in fact I must do that so I can have a better feel for what we did last year and how it might relate to and impinge upon our 1989 plans. When that occurs, if I identify anything of interest, I will share it with you.

Our winter is going on for a long time--its colder than anyone can remember since the winter of 1948-49 (that I remember and it has always been my reference year) and during the first part of February we had 27" of snow here in Provo over a 3-day period. We survived it, however, and all is going well with us, and we trust it is the same for you.

Thanks so much for your support.

Sincerely,

R. D. Horrocks, Professor
and Chairman

BRIGHAM YOUNG
UNIVERSITY

THE GLORY OF GOD
IS INTELLIGENCE

31 July 1989

Dr. Bronson Gardner
Standard Oil Engineered Materials Company
6180 Cochran Road
P. O. Box 391316
Solon, OH 44139

Dear Bronson:

I have completed the soil water and plant stress measurements on the wheat for the 1989 growing season. All has gone quite well, but I haven't had time to summarize the 1989 data, nor, for that matter, the 1988 data either. As I have time to summarize the data, I will then share with you anything that is appropriate and related to the Scheduler. I am shipping both Schedulers back to you today. They should arrive sometime within the next two weeks via UPS.

You may be aware that I am planning on a 1-year professional development leave to the Univerisity of California-Davis. My plans are now finalized and I will be leaving here on the 15 August 1989, and I will return to BYU on about 1 August 1990. I'm looking forward to the change and to the possibility of refurbishing my research capabilities. I'll actually be working in the area of 'expert systems,' mathematical modelling, and computer simulation of cotton with the cotton group at UC-Davis, which is headed by Dick Plant (very appropriate name, don't you think). My orginal contact, and reason for going to UC-Davis at this time, is Tom Kerby, the cotton physiologist whom I had known when he was a graduate student at the University of Arizona and I was on leave there.

I have appreciated your generosity during the past two years. I'm sure that after I have summarized this research that I'll be able to assess my needs with respect to use of a Scheduler or similar machine in my research program and my advisory farm management duties. At that time I will be in contact with you.

I hope I'll see you in Las Vegas at the BYU breakfast.

Best Wishes

R. D. Horrocks,
Professor of Agronomy

DEPARTMENT OF AGRONOMY AND HORTICULTURE
275 WIDB
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH 84602
(801) 378-2760

CARBORUNDUM

The Carborundum Company
Instrument Technologies
6180 Cochran Road
P.O. Box 391377
Solon, Ohio 44139

Telephone 216 349-6895
Telefax 216 349-6897

October 26, 1989

Dr. Clint Shock
Malheur Experiment Station
Oregon State University
Route 1, Box 620
Ontario, Oregon 97914

Dear Clint:

The Carborundum Company appreciates greatly the contribution your research has made in furthering our technical and agronomic understanding of the Crop Water Stress Index as used in the Scheduler^{R} Plant Stress Monitor. This work has been extremely helpful in assisting growers throughout the United States (and in several foreign countries) to more effectively use this technology.

In recognition of your contributions, The Carborundum Company has honored you with their Centers of Excellence award, which is enclosed.

I extend to you my heartfelt congratulations. Thank you for all you have done. I look forward to our continued association.

Sincerely,

Bronson Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

Enclosure

Scheduler®

Plant Stress Monitor

Centers of Excellence Award

This certifies that Dr. Clint Shock **has been designated as a Center of Excellence, dedicated to quality research and/or teaching related to the Application, Methodology and Use of Instrumentation to properly manage plant stress.**

Date October 26, 1989 **Signed** Bronson Gardner

Bronson Gardner, Ph.D.
Product Technical Manager
CARBORUNDUM

© GOES 462-1/2

LITHO IN U.S.A.

CARBORUNDUM

The Carborundum Company
Instrument Technologies
6180 Cochran Road
P.O. Box 391377
Solon, Ohio 44139

Telephone 216 349-6881
Facsimile 216 349-6897

March 15, 1989

Dear Colleague:

The 1988 Centers of Excellence program sponsored by Standard Oil Engineered Materials Co. was a great success. The purpose of this program was to financially assist the research, teaching, and extension functions of universities, state, and federal government agencies to acquire our instrumentation while stretching their budgets as far as possible.

We are pleased to announce that, the Centers of Excellence Program will continue through 1989, with one key change: grants (in the form of a price reduction) on our entire product line will be made to all qualifying institutions. Enclosed is a description of the 1989 Centers of Excellence program.

We are also pleased to announce two new products: The Croplink™ Crop Monitoring System (infrared-telemetry based weatherstation) and the Weatheredge™ Infrared Thermometer. This equipment provides a low-cost solution to many data acquisition and crop monitoring problems. To discuss further how these new products can be successfully implemented into your research or extension plans, please telephone toll free at (800) 356-0458. We have also attached a current price list in case you are interested in purchasing instruments from the remainder of your 1988 budgets.

Sincerely,

Bronson R. Gardner

Bronson R. Gardner, Ph.D.
Product Technical Manager

BRG/lb

Enclosures

CENTERS OF EXCELLENCE PROGRAM

Purpose: Reward those institutions or agencies interested in the development and furtherment of environmental and crop temperature information.

Our intent is to financially aid those organizations wishing to use this type of instrumentation for the purpose of broadening its application, improving scientific method, and/or teaching about the use of environmental and crop temperature information.

Awards will be made solely at the discretion of Standard Oil Engineered Materials Company.

Program Awards:

Award: We will make awards in the form of a credit against the suggested retail price of our products (see attached sheet).

Offer Expires: October 31, 1989

To Quality: Contact

STANDARD OIL ENGINEERED MATERIALS COMPANY
Sensor Technologies
P. O. Box 391316
Solon, OH 44139

ATTN: Dr. Bronson R. Gardner
Phone: (800) 356-0458

Scneauier™

Plant Stress Monitor

Centers of Excellence Award

This certifies that _____ has been designated as a Center of Excellence, dedicated to quality research and/or teaching related to the Application, Methodology and use of instrumentation to properly manage plant stress.

Date_____ Signed_____

Bronson Gardner, Ph.D.
Product Technical Manager
Standard Oil Engineered Materials

A unit of the original Standard Oil Company founded in Cleveland, Ohio in 1870.

© GOES 462-1/2

LITHO IN U.S.A.

United States Department of Agriculture
Agricultural Research Service
Northern Plains Area
Central Great Plains Research Station
P.O. Box K
40335 Cty Rd GG
Akron, CO 80720

19 April 1991

Dr. Bronson R. Gardner
SOHIO
4440 Warrensville Center Road
Cleveland, Ohio 44128

Dear Bronson:

I sensed from your phone call yesterday that you would like to see something in black and white regarding the manuscript revision. So I have quickly finished the first of the two companion papers and am sending it to you to see what your comments will be. I will continue to work on part two, which will most likely be entitled, "Interpreting the Crop Water Stress Index. II. Sampling procedures and interpretation." The general outline of this paper will be:

A. Introduction
    1. Reference to part 1
    2. Need for sampling standards
    3. General statement on CWSI relationships to other water stress parameters
B. Sampling procedures
    1. Equipment/instrumentation concerns
    2. Time of day/environmental concerns
    3. Plant material concerns
    4. Making the measurement
C. Interpretation and relationships to other water stress parameters.
    1. Relating CWSI to crop productivity
    2. Review of previous work relating CWSI to extractable water in the active root zone, leaf water potential, stomatal resistance, leaf photosynthesis, leaf transpiration, etc

As I have said, I plan on submitting this manuscript to the ASA publication, Journal of Production Agriculture, because one of their preferred types of papers is a "synthesis or interpretive review or state of the art paper...that transfers production-oriented scientific and technological information on agronomy in concert with other disciplines..."

Let me know if you don't like what I have done to your original manuscript. Electronic word processing is a wonderful thing.

Sincerely,

David

David C. Nielsen
Research Agronomist

P.S. See p. 13, lines 7-8. I need a correct citation for this. It is the original manuscript that you gave me that I am working from. Was it from an ASA meeting, or an ASAE meeting?

AGRICULTURAL
EXPERIMENT STATION
Malheur Experiment Station

OREGON
STATE
UNIVERSITY

595 Onion Avenue
Ontario, Oregon
97914

Telephone
503·889·2174
Fax
503·889·7831

November 9, 1991

TO: David Nielsen
Bronson Gardner

FROM: Clint Shock

SUBJECT: CWSI papers

David is to be congratulated for his vast improvements. I have made a number of suggestions on the text. In paper "I" page 12 paragraph 1 needs some rewriting because we assume too much knowledge in the hypothetical example (Figure 2).

In the second paper p. 4 line 11 should read "An additional" rather than "A more important." Excessive wind speeds invalidate CWSI readings and can be just as devastating as low solar radiation. I suggest that we also send the manuscripts through the Oregon State University review procedure.

Please see the comments and corrections in the text.

enclosures
CS/mj

F4T
Bronson

United States Department of Agriculture
Agricultural Research Service
Northern Plains Area
Central Great Plains Research Station
P.O. Box K
40335 Cty Rd GG
Akron, CO 80720

C.C. Shock
Superintendent
Malheur Experiment Station
Oregon State University
595 Onion Avenue
Ontario, Oregon 97914

Dear Clint:

Please excuse me for not getting my comments regarding this manuscript back to you sooner. We had annual reports to get written and a presentation for our station advisory committee to prepare, and my review of this paper just kept getting shoved back.

Most of my comments are on the manuscript, but let my go through some of them in more detail.

1. I still believe that this paper would serve a better purpose by being published in Applied Agricultural Research or Journal of Production Agriculture. The readership of these two journals would greatly benefit from the experiences and tutorial-type information reported.

2. The paper is quite lengthy, and you should consider attempting to split it into two companion papers if possible. My suggestion would be to have the first paper deal with history, theory, and baselines, and have the second paper deal with sampling procedures, routine use, and interpretation. Of course, this would require separate introductions and summaries be written for both papers.

3. I think the paper will read better if the frequent references to the Carborundum experience are removed. Not every experience reported in this manuscript is unique (or proprietary) to the Carborundum Company. Both you and I and many others working with infrared thermometry have had similar experiences.

4. The discussion of the change in CWSI scale by a factor of 10 is too lengthy. It probably is enough to say that in transferring this technology to producers and growers, changes in magnitude on a scale of 0-10 are more easily understood than on a scale of 0-1.

5. The paper has many errors in literature citations, some cited incorrectly in the text, and some not appearing in the reference list. These need to be checked thoroughly.

6. The terms "moisture stress" and "water stress" are used interchangeably throughout the paper, but you should be consistent and use just one. I prefer water stress.

7. Figure 2 needs more detail to be easily understood.

8. Equations are not numbered correctly.

9. References are needed to support the statement that "Several techniques exist in the literature for estimating MAX." There definitely needs to be a discussion regarding Idso's definition of MAX which floats with ambient air temperature, and why it is preferable to define MAX which does not change.

10. There is no discussion about how the CWSI trend curve (Fig. 3) is derived.

11. Fig. 4 is does not add much to the discussion of different classes of crops having different levels of stress tolerance. I would delete it.

12. I don't think that the lengthy discussion and derivation to show how leaf water potential is influenced by the same environmental parameters as CWSI is appropriate for this paper. I would rather replace this whole section with a review of literature which documents the number of studies showing relationships between CWSI and leaf water potential, stomatal conductance, leaf photosynthesis, leaf transpiration, and available water in the active root zone.

13. I don't understand what is meant by the "specific calculation procedures used in the Scheduler" which are proprietary. Isn't the actual calculation procedure just the equation given earlier in the manuscript? There is probably no benefit to this manuscript in making a point that the Carborundum has proprietary, unavailable information. If there is a point that I am not getting from this paragraph, then it needs to be rewritten more clearly.

14. I have some question regarding the statement made in point j. of the Sampling Guidelines discussion. In large fields you would not be out of the fully adjusted boundary layer even at two meters above the crop canopy. That is not to say that there aren't significant gradients of temperature and humidity within and above crop canopies, but my experience has been that there have been no problems when measuring within 1 m of the top of the crop canopy. In fact, when we have measured single leaves using an IRT within a few centimeters of a leaf, right on top of the canopy, we still get very good results. I would like to hear more about what your experience with these types of measurements have been.

There is a lot of valuable information and experience in this paper, and I look forward to seeing it in print. Please let me know if you have questions about my comments, and if there is anything you would like me to do.

Sincerely,

David C. Nielsen
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cc: Bronson R. Gardner

RESEARCH AGREEMENT

THIS AGREEMENT, effective this _____ day of _____, 198__, between Standard Oil Engineered Materials Company, a Corporation of the State of New York, referred to hereinafter as "STANDARD OIL", and _____ to be referred to hereinafter as "COOPERATOR". STANDARD OIL and the COOPERATOR will be studying and demonstrating the use of STANDARD OIL's proprietary instrument. In consideration of the rights and obligations herein set forth below the parties agree as follows:

STANDARD OIL will provide COOPERATOR with the instrument for determining irrigation requirements for a test area. STANDARD OIL will maintain ownership of the instrument and COOPERATOR will return the instrument to STANDARD OIL at the completion of the program or upon receipt of written notice from STANDARD OIL. STANDARD OIL will instruct the COOPERATOR in the intended use of the instrument. The COOPERATOR will use reasonable care in handling and storage of the instrument which shall include adequate security. COOPERATOR will be responsible for using the instrument for collecting data. COOPERATOR will be responsible for maintaining records of irrigation and rainfall on the test area by location, date and time for purposes of result comparison. COOPERATOR will not tamper with the instrument. Cooperator agrees to provide a copy of all data relevant to the instrument to STANDARD OIL upon request.

STANDARD OIL will have reasonable access to the instrument during the program for calibration, maintenance, repair, data retrieval and the like during the term of the program. STANDARD OIL will not be liable for damages that may occur to the crops in the test area by following the instrument readings.

Information such as designs, data, drawings, know-how, observations, techniques, inventions and the like relating to the instrument shall be exclusive property of STANDARD OIL and all rights, title and interests shall reside with STANDARD OIL. All information provided by STANDARD OIL pursuant to this Agreement shall be treated as confidential information. The COOPERATOR agrees at all times that the COOPERATOR will make no disclosure of the confidential information to any third party unless expressly authorized in writing by STANDARD OIL to do so. Information, data, know-how, observations, techniques and the like not related to the instrument are not affected by this Agreement.

COOPERATOR agrees that all inventions, improvements and developments in the instrument conceived or developed as a result of COOPERATOR's participation with STANDARD OIL in this program, shall be disclosed to STANDARD OIL but otherwise shall be held confidential as indicated above, and COOPERATOR agrees, at STANDARD OIL's expense, to secure all intellectual property rights therein to STANDARD OIL by signing Patent applications, assignments and any other papers.

It is understood that in rendering COOPERATOR's services to STANDARD OIL, COOPERATOR will be acting as an independent contractor and not as STANDARD OIL's agent.

If COOPERATOR agrees to the above terms and conditions, please indicate your acceptance in the space provided below and return one copy of this to STANDARD OIL. This shall then constitute an agreement between us.

STANDARD OIL
ENGINEERED MATERIALS COMPANY

BY: _____

DATE: _____

COOPERATOR

BY: _____

DATE: _____